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RESPIRATORY CARE

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EDITORIAL

Therapist-Directed Protocols: Their Time Has Come

ORIGINAL CONTRIBUTIONS

Trial of a Therapist-Directed Protocol for Weaning Bronchodilator Therapy in Children

Use of a Protocol to Improve Oxygen Administration and Preserve Resources in a Community Hospital

Monitoring Quality for a Respiratory Care Protocol Service

Effects of Inspiratory Time and Other Variables on Delivered Oxygen Fraction in the Quantum PSV Noninvasive Ventilator

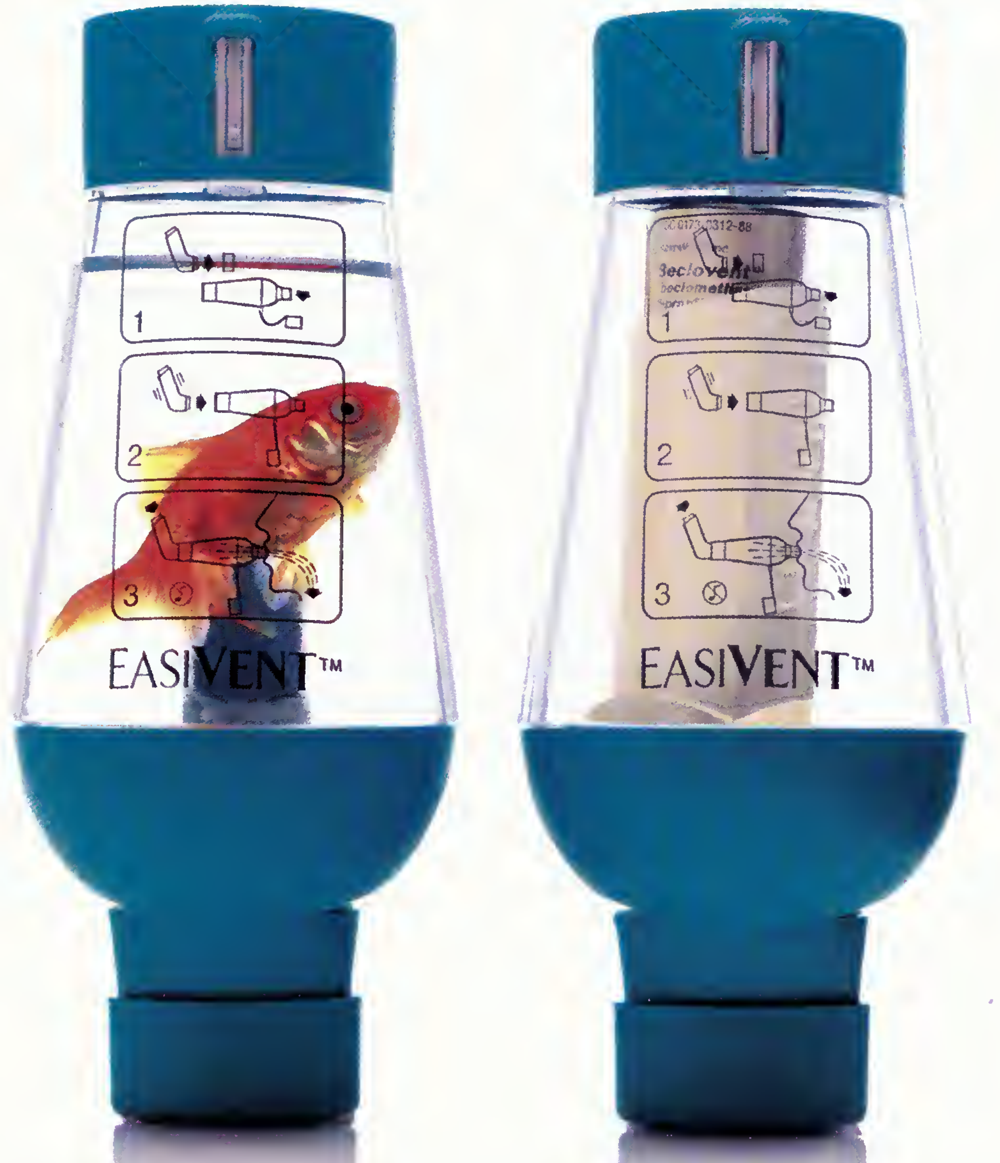
CASE REPORT

A Young Adult with Near-Fatal Adenovirus Pneumonia

SPECIAL ARTICLES

Implementing a Respiratory Care Protocol Service

Staffing and Training Issues for a Respiratory Care Protocol Service



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Source: Barker SJ, Novak S, Morgan S. The Performance of Three Pulse Oximeters During Low Perfusion in Volunteers. *Anesthesiology* 1997;87(3A):A409.

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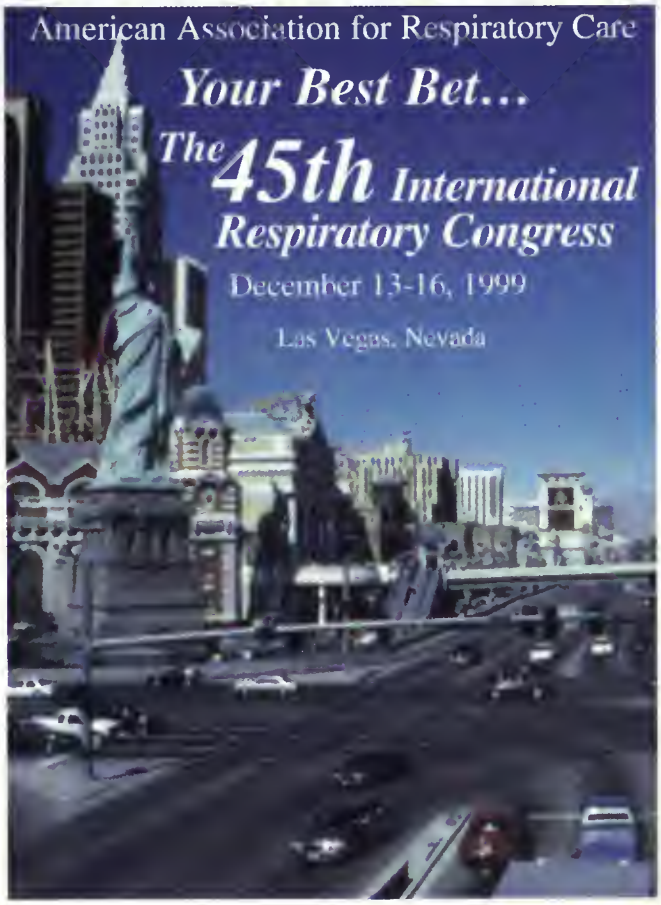
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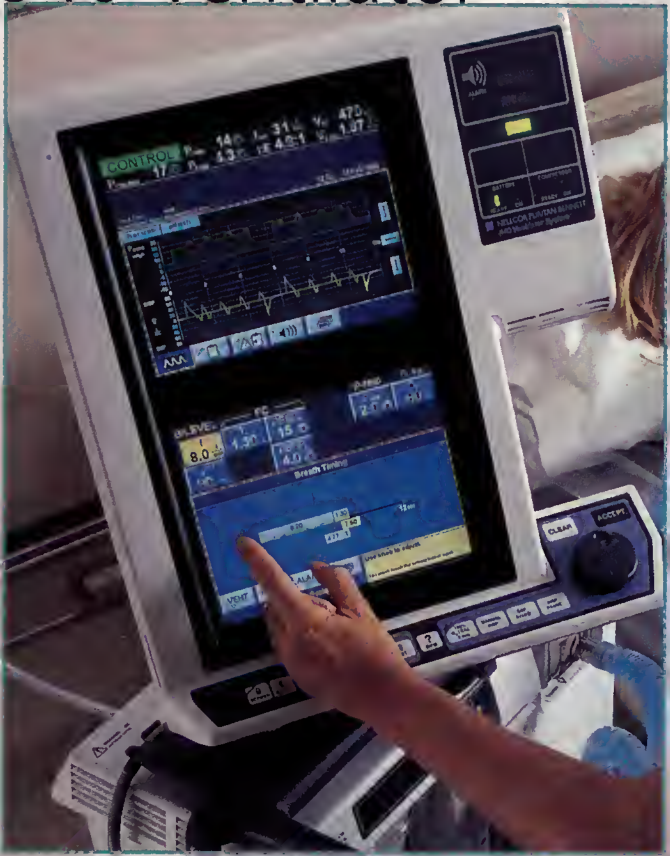

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Evaluation of Airways in Obstructive Pulmonary Disease Using High-Resolution Computed Tomography (review)—King GG, Muller NL, Pare PD. Am J Respir Crit Care Med 1999; 159(3):992-1004.

Tracheo-Innominate Artery Fistula after Tracheostomy—Kapural L, Sprung J, Gluncic I, Kapural M, Andelinovic S, Primorac D, Schoenwald PK. Anesth Analg 1999;88(4):777-780.

Comparison of the Laryngeal Mask Airway and Cuffed Oropharyngeal Airway: Alternative Hypotheses (letter)—Behringer EC. Anesth Analg 1999;88(4):961-962.

Bronchopulmonary Dysplasia—No Simple Solution (editorial)—Martin RJ, Walsh-Sukys MC. N Engl J Med 1999;340(13):1036-1038.

Total Parenteral Nutrition in the Critically Ill Patient—Birmingham CL. Lancet 1999; 353(9159):1116-1117.

Sham Continuous Positive Airway Pressure for Placebo-Controlled Studies in Sleep Apnoea—Farre R, Hernandez L, Montserrat JM, Rotger M, Ballester E, Navajas D. Lancet

When Do Infants Need Additional Inspired Oxygen? A Review of the Current Literature—Poets CF. Pediatr Pulmonol 1998;26(6): 424.

There is considerable uncertainty regarding the oxygen saturation threshold below which additional inspired oxygen should be given to infants with acute or chronic lung disease. In the absence of data from controlled studies, recommendations can only be based on reference values for healthy infants and on observational studies regarding the pathophysiological effects of acute and chronic hypoxia. Reference values for pulse oximeter saturations (S_{pO_2}) in term and preterm infants show that during normal breathing 95% of infants maintain S_{pO_2} at or above 93-97%, depending on age. Studies of infants with chronic lung disease (CLD) show that (1) when S_{pO_2} was kept at $\geq$ 93% by administration of home oxygen, rates of sudden infant death were reduced; (2) weight gain was significantly better when S_{pO_2} was maintained at $\geq$ 93-95%, (3) increasing S_{pO_2} from 82 to 93% by delivering low-flow oxygen resulted in a 50% reduction in pulmonary artery pressure, (4) O_2 administration to mildly hypoxemic infants (S_{pO_2} 89%) caused a 50% decrease in airway resistance, and (5) low-flow oxygen reduced the frequency of intermittent hypoxemic episodes, even in infants who had values of $\geq$ 90% at rest. Based on these data, it is recommended that oxygen therapy should be considered in infants whose baseline S_{pO_2} is $<$ 93%, and that S_{pO_2} should be maintained at $\geq$ 95% when infants are managed at home.

An In Vitro Validation of a Commercially Available Metabolic Cart Using Pediatric Ventilator Volumes—Webster PA, King SE, Torres A Jr. Pediatr Pulmonol 1998;26(6):405.

Our objective was to determine the validity of the SensorMedics 2900 Metabolic Measurement Cart (SensorMedics Corp., Yorba Linda, CA) for use at pediatric ventilator volumes by designing an in vitro validation study. The study was performed using a previously described nitrogen dilution, carbon dioxide infusion technique in which known amounts of nitrogen (N_2) and carbon dioxide (CO_2) are infused while a test lung is ventilated. Metabolic measurements were made at tidal volumes (V_T) varying from 50-500 mL at a peak end-expiratory pressure (PEEP) of 0 and 12 cm H_2O and at inspiratory oxygen fractions (F_{IO_2}s) ranging from 0.21-0.60. Each study was repeated six times to assess reproducibility of measurements. At a PEEP of 0 cm H_2O, the measurement of oxygen consumption ($\dot{V}_{O_2}$), carbon dioxide production ($\dot{V}_{CO_2}$), and minute ventilation ($\dot{V}_E$) were all within ±10% of predicted values at all F_{IO_2}s except when V_T was 50 mL. When PEEP was increased to 12 cm H_2O, error in measurement of $\dot{V}_{O_2}$ increased and became unacceptably large as F_{IO_2} was increased. Each study consisted of six trials, and results showed acceptable reproducibility as demonstrated by narrow 95% confidence intervals. For V_T of 100-500 mL, the metabolic monitor provided accurate and reproducible results under in vitro testing conditions when PEEP was low. Accurate results could not be obtained with a V_T of 50 mL or at elevated PEEP.

Safety of Revaccination with Pneumococcal Polysaccharide Vaccine—Jackson LA, Benson P, Sneller VP, Butler JC, Thompson RS, Chen RT, et al. JAMA 1999;281(3):243.

CONTEXT: Revaccination of healthy adults with pneumococcal polysaccharide vaccine (PPV) within several years of first vaccination has been associated with a higher than expected frequency and severity of local injection site reactions. The risk of adverse events associated with revaccination of elderly and chronically ill persons 5 or more years after first vaccination, as is currently recommended, has not been well defined. OBJECTIVE: To determine whether revaccination with PPV at least 5 years after first vaccination is associated with more frequent or more serious adverse events than those following first vaccination. DESIGN: Comparative intervention study conducted between April 1996 and August 1997. PARTICIPANTS: Persons aged 50 to 74 years either who had never been vaccinated with PPV (n = 901) or who had been vaccinated once at least 5 years prior to enrollment (n = 513). INTERVENTION: PPV vaccination. MAIN OUTCOME MEASURES: Postvaccination local injection site reactions and prevaccination concentrations of type-specific antibodies. RESULTS: Those who were revaccinated were more likely than those who received their first vaccinations to report a local injection site reaction of at least 10.2 cm (4 in) in diameter within 2 days of vaccination: 11% (55/513) vs 3% (29/901) (relative risk [RR], 3.3; 95% confidence interval [CI], 2.1-5.1). These reactions resolved by a median of 3 days following vaccination. The highest rate was among revaccinated patients who were immunocompetent and did not have chronic illness: 15% (33/228) compared with 3% (10/337) among comparable patients receiving their first vaccinations (RR, 4.9; 95% CI, 2.4-9.7). The risk of these local reactions was significantly correlated with prevaccination geometric mean antibody concentrations. CONCLUSIONS: Physicians and patients should be aware that self-limited local injection site reactions occur more frequently following revaccination compared with first vaccination; however, this risk does not represent a contraindication to revaccination with PPV for recommended groups.

Efficacy Of Antiseptic-Impregnated Central Venous Catheters in Preventing Catheter-Related Bloodstream Infection: A Meta-Analysis—Veenstra DL, Saint S, Saha S, Lumley T, Sullivan SD. JAMA 1999;281(3):261.

CONTEXT: Central venous catheters impregnated with chlorhexidine and silver sulfadiazine have recently been introduced for the prevention of catheter-related infections. However, there remains some uncertainty regarding the efficacy of these catheters because of conflicting reports in the literature. OBJECTIVE: To evaluate the efficacy of chlorhexidine-silver sulfadiazine-impregnated central venous catheters in the prevention of catheter-related bloodstream infection. DATA SOURCES: Studies identified from a computerized search of the MEDLINE database from January 1966 to January 1998, reference lists of identified articles, and queries of principal investigators and the catheter manufacturer. STUDY SELECTION: Randomized trials comparing chlorhexidine-silver sulfadiazine-impregnated central venous catheters with nonimpregnated catheters were included. The outcomes assessed were catheter colonization and catheter-related bloodstream infection confirmed by catheter culture. DATA EXTRACTION: Twelve studies met the inclusion criteria for catheter colonization and included a total of 2611 catheters. Eleven studies with a total of 2603 catheters met the inclusion criteria for catheter-related bloodstream infection. Most patients in these studies were from groups considered to be at high risk for catheter-related infections. Summary statistics were calculated using Mantel-Haenszel methods under a fixed-effects model. DATA SYNTHESIS: The summary odds ratio for catheter colonization was 0.44 (95% confidence interval [CI], 0.36-0.54; P<.001), indicating a significant decrease in catheter colonization associated with impregnated catheters. The studies examining the outcome of primary interest, catheter-related bloodstream infection, had a summary odds ratio of 0.56 (95% CI, 0.37-0.84; P = .005). CONCLUSIONS: Central venous catheters impregnated with a combination of chlorhexidine and silver sulfadiazine appear to be effective in reducing the incidence of both catheter colonization and catheter-related bloodstream infection in patients at high risk for catheter-related infections.

Nonsurgical Causes of Pneumoperitoneum—Mularski RA, Ciccolo ML, Rappaport WD. West J Med 1999;170(1):41.

The radiographic manifestation of free air in the peritoneal cavity suggests serious intra-abdominal disease and the need for urgent surgical management. Yet, about 10% of all cases of pneumoperitoneum are caused by physiologic processes that do not require surgical management. We retrospectively reviewed cases of nonsurgical causes of pneumoperitoneum at the 2 teaching hopitals of a university medical center between January 1990 and December 1995. Successful management by observation and supportive care without surgical intervention was defined as the diagnostic feature of nonperforation. Failure of a laparotomy to delineate a surgical cause or to result in a reparative procedure is congruent with a nonsurgical cause of pneumoperitoneum. During this period, 8 patients (6 men and 2 women; mean age, 61 years) were identified with nonsurgical causes of pneumoperitoneum. Two patients underwent negative laparotomy, and the other 6 were successfully managed nonoperatively and discharged from the hospital. In 6 patients, a cause of the pneumoperitoneum was identified. The causes may be grouped under the following categories: postoperatively retained air, thoracic, abdominal, gynecologic, and idiopathic. In our review of the literature, 61 of 139 reported cases underwent surgical treatment without evidence of perforated viscus. To avoid unnecessary surgical procedures, both primary medicine physicians and surgeons need to recognize nonsurgical causes of pneumoperitoneum. Conservative management is warranted in the absence of symptoms and signs of peritonitis.

Dyspnea in Patients with Chronic Obstructive Pulmonary Disease: Does Dyspnea Worsen Longitudinally in the Presence of Declining Lung Function?—Lareau SC, Meek PM, Press D, Anholm JD, Roos PJ. Heart Lung 1999;28(1):65.

OBJECTIVE: To determine the direction and rate of change in the symptom of dyspnea in patients with chronic obstructive pulmonary disease (COPD) whose lung function has worsened over time. DESIGN: Secondary analysis of a longitudinal data set. SETTING: Outpatient clinic. PATIENTS: Thirty-four medically stable male subjects with chronic obstructive pulmonary disease studied for 5.3 ± 3.5 years, with a mean reduction in FEV_1 over the period studied of 330.9 ± 288.0 mL. Subjects were 63.3 ± 5.5 years of age at entry into the study-.OUTCOME MEASURES: Dyspnea and functional status scores were obtained using the Pulmonary Functional Status and Dyspnea Questionnaire. RESULTS: There was no significant difference in reports of dyspnea from the beginning to the end of the study, despite significant reductions in lung function. Of all activities studied, dyspnea when raising arms overhead was the only activity showing a relationship to the slope of change in FEV_1 %. CONCLUSION: These findings suggest that, although patients with chronic lung disease experience varying degrees of deterioration in lung function longitudinally, there is no evidence that they report worsening of dyspnea in tandem with these physiologic changes. In this study, patient ratings of dyspnea longitudinally were not directly linked to changes in lung impairment.

The Detection of Airborne Mycobacterium Tuberculosis Using Micropore Membrane Air Sampling and Polymerase Chain Reaction. Mastorides SM, Oehler RL, Greene JN, Sinnott JT 4th, Kranik M, Sandin RL. Chest 1999;115(1):19.

STUDY OBJECTIVES: Mycobacterium tuberculosis (MTb) bacilli are carried on airborne droplet nuclei produced by aerosolization that can occur from coughing, talking, or even singing. Because of their prolonged period of suspension, they can be filtered from the air onto a porous medium and readily detected using polymerase chain reaction (PCR). DESIGN: Prospective cohort analysis. SETTING: Samples of circulating air were collected over a 12-month period from within the rooms of 10 hospitalized patients who were under respiratory isolation to rule out MTb infection. A small laboratory pump was used to draw ambient air at a rate of 2 L/min over a 6-h period through a 0.2-micron polycarbonate membrane filter placed near the patient's bed. Analysis of the membrane filters was conducted using PCR. Sputum cultures for MTb were performed simultaneously, and the results of smears stained for acid-fast bacilli (AFB) were noted. MEASUREMENTS AND RESULTS: MTb complex was successfully detected by PCR in six of seven patients in whom sputum MTb cultures were subsequently positive, and in zero of three with subsequently negative sputum cultures. Sampling in one patient with a positive culture, in whom PCR results were negative, was only carried out for 2 h due to pump malfunction. One of the six PCR-positive patients was AFB-smear negative at the time of air sampling. CONCLUSIONS: Our preliminary findings indicate that the technique of Micropore membrane air sampling with PCR analysis has important applications in the epidemiology and diagnosis of MTb.

Tuberculous Pleural Effusion in Children—Merino JM, Carpintero I, Alvarez T, Rodrigo J, Sanchez J, Coello JM. Chest 1999;115(1):26.

STUDY OBJECTIVES: To describe the age distribution, clinical, laboratory, radiographic, and bacteriologic findings of pediatric patients with tuberculous pleural effusion. DESIGN: A retrospective study. PATIENTS AND METHODS: We have identified all cases of primary pulmonary tuberculosis in children < 18 years, reported to the health department. We have collected information from medical records regarding demographics, clinical findings, bacteriologic results, and evolution. Chest radiographs obtained at the time of initial evaluation were reviewed independently by two groups of radiologists who were blind to the clinical and epidemiologic data. RESULTS: Between January 1983 and December 1996, 175 children < 18 years were diagnosed as having primary pulmonary tuberculosis. Among them, 39 patients (22.1%) showed pleural effusion on chest radiograph. The mean age of patients with tuberculous pleural effusion was significantly higher (13.52±0.5 years vs 6.97±0.42 years). The sensitivity of the tuberculin test is 97.4% for an induration ≥ 5 mm. Pleural fluid analysis shows a lymphocytic exudative effusion. Chest radiograph review showed unilateral pleural effusion in all cases. Pleural effusion was the sole radiographic manifestation in 41% of cases. Parenchymal disease is associated in 23 cases (59%). Bacteriologic confirmation of tuberculosis was achieved in 22 cases (56.4%). Cultures of pleural fluid and biopsy material both yielded Mycobacterium tuberculosis in 15 of 34 (44.1%) and 12 of 18 (66.6%), respectively, for samples under study. Pleural biopsy specimens showed granulomatous inflammation in 18 of 23 cases (78.3%). Antituberculous therapy for 6 to 9 months was effective in all cases. Transient side effects occurred in 1 of 39 patients (2.9%). CONCLUSIONS: Pleural effusion accounts for 22.1% of cases of pediatric pulmonary tuberculosis. Parenchymal consolidation is the most common associated radiographic finding. Bacteriologic confirmation was achieved in 56.4% of cases. A short course of chemotherapy is effective.

The Effect of High-Dose Inhaled Beclomethasone Dipropionate in Patients with Stable COPD—Nishimura K, Koyama H, Ikeda A, Tsukino M, Hajiro T, Mishima M, Izumi T. Chest 1999;115(1):31.

BACKGROUND: The benefits of inhaled corticosteroids in the management of COPD are less apparent than they are in asthma therapy, and the potential for adverse systemic effects of high-dose inhaled corticosteroids has been recognized recently. It is therefore essential to know the maximal obtainable benefits in order to assess the risk/benefit ratio of this treatment. PURPOSE: The aim of this study was to investigate the maximal obtainable benefits of high-dose inhaled corticosteroids, 3 mg/d of beclomethasone dipropionate (BDP), when used in combination with adequate doses of regular bronchodilators in patients with stable COPD. STUDY DESIGN: Thirty patients with stable COPD completed a randomized, double-blind, placebo-controlled cross-over trial with either 3 mg/d of BDP or with a matching placebo using a metered-dose inhaler with a spacer device for 4 weeks during each treatment period. All of the patients continued to inhale both 400 microg of salbutamol qid and 80 microg of ipratropium bromide qid. RESULTS: The mean prebronchodilator FEV$_1$ was 0.97±0.35 L during the placebo period and 1.08±0.38 L during the BDP period ($p < 0.001$). While on BDP, five patients demonstrated a response in their FEV$_1$ of more than 8.5% of the predicted value, which was above the range that covered 95% of the distribution of the placebo response. The mean absolute improvement in the FEV$_1$ in these 5 objective responders was 0.34±0.10 L, compared to 0.06±0.09 L in the 25 objective nonresponders. Symptom scores for wheezing and dyspnea were significantly better with BDP than with placebo. Hoarseness and sore throat were associated more with BDP treatment. CONCLUSION: Although a considerable minority of patients benefited substantially from this treatment, the overall outcome does not seem to justify the widespread use of this treatment in the light of increasing recognition of the potential adverse systemic effects of high-dose inhaled corticosteroids.

Lung Volumes In 4,774 Patients with Obstructive Lung Disease—Dykstra BJ, Scanlon PD, Kester MM, Beck KC, Enright PL. Chest 1999;115(1):68.

STUDY OBJECTIVES: To determine the correlates of static lung volumes in patients with airways obstruction, and to determine if static lung volumes differ between asthma and COPD. PATIENTS AND METHODS: We examined the data from all of the adult patients (mean age of 69) who were referred to a pulmonary function laboratory from January 1990 through July 1994 with an FEV$_1$ /FVC ratio of < 0.70 and tested using a body plethysmograph. Correlates were determined using regression analysis. MEASUREMENTS AND RESULTS: Of the 4,774 patients observed with evidence of airways obstruction, 61% were men. Self-reported diagnoses included asthma, 19%; emphysema or COPD, 23%; chronic bronchitis, 1.5%; and alpha1-antiprotease deficiency, 0.6%. Fifty-six percent of the patients did not report a respiratory disease. The degree of hyperinflation, as determined by the residual volume (RV)/total lung capacity (TLC) ratio, or the RV % predicted (but not the TLC % predicted), was strongly associated with the degree of airways obstruction (the FEV$_1$ % predicted). Patients with moderate to severe airways obstruction and high RV and TLC levels were more likely to have COPD than asthma. Of the 1,872 patients with a reduced vital capacity determined by spirometry testing, 87% had hyperinflation as defined by the RV/TLC, and 9.5% had a low TLC (with less severe airways obstruction). CONCLUSION: In patients found to have airways obstruction by spirometry, the additional measurement of static lung volumes added little to the clinical interpretation

Improvements in Lung Function, Exercise, and Quality of Life in Hypercapnic COPD Patients after Lung Volume Reduction Surgery. O'Brien GM, Furukawa S, Kuzma AM, Cordova F, Criner GJ. Chest 1999;115(1):75.

STUDY OBJECTIVE: To determine the impact of preoperative resting hypercapnia on patient outcome after bilateral lung volume reduction surgery (LVRS). METHODS: We prospectively examined morbidity, mortality, quality of life (QOL), and physiologic outcome, including spirometry, gas exchange, and exercise performance in 15 patients with severe emphysema and a resting P_{aCO_2} of > 45 mm Hg (group 1), and compared the results with those from 31 patients with a P_{aCO_2} of < 45 mm Hg (group 2). RESULTS: All preoperative physiologic and QOL indices were more impaired in the hypercapnic patients than in the eucapnic patients. The hypercapnic patients exhibited a lower preoperative FEV$_1$, a lower diffusing capacity of the lung for carbon monoxide, a lower ratio of P_{aO_2} to the fraction of inspired oxygen, a lower 6-min walk distance, and higher oxygen requirements. However, after surgery both groups exhibited improvements in FVC (group 1, $p < 0.01$; group 2, $p < 0.001$), FEV$_1$ (group 1, $p=0.04$; group 2, $p < 0.001$), total lung capacity (TLC; group 1, $p=0.02$; group 2, $p < 0.001$), residual volume (RV; group 1, $p=0.002$; group 2, $p < 0.001$), RV/TLC ratio (group 1, $p=0.03$; group 2, $p < 0.001$), P_{aCO_2} (group 1, $p=0.002$; group 2, $p=0.02$), 6-min walk distance (group 1, $p=0.005$; group 2, $p < 0.001$), oxygen consumption at peak exercise (group 1, $p=0.02$; group 2, $p=0.02$), total exercise time (group 1, $p=0.02$; group 2, $p=0.02$), and the perceived overall QOL scores (group 1, $p=0.001$; group 2, $p < 0.001$). However, because the magnitude of improvement was sim-

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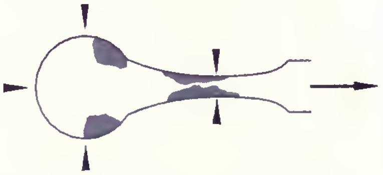

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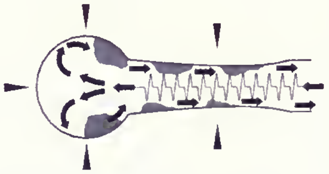

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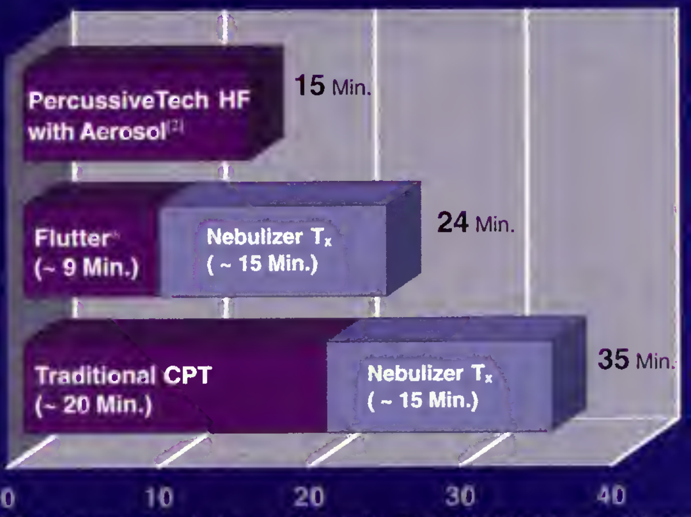

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ilar in both groups, and the hypercapnic group was more impaired, the spirometry, lung volumes, and 6-min walk distance remained significantly lower post-LVRS in the hypercapnic patients. There was no difference in mortality between the groups (p=0.9). CONCLUSIONS: Patients with moderate to severe resting hypercapnia exhibit significant improvements in spirometry, gas exchange, perceived QOL, and exercise performance after bilateral LVRS. The maximal achievable improvements in postoperative lung function are related to preoperative level of function; however, the magnitude of improvement can be expected to be similar to patients with lower resting P_{aCO_2} levels. Patients should not be excluded from LVRS based solely on the presence of resting hypercapnia. The long-term benefit of LVRS in hypercapnic patient remains to be determined.

Lack of Correlation Of Symptoms with Specialist-Assessed Long-Term Asthma Severity—Osborne ML, Vollmer WM, Pedula KL, Wilkins J, Buist AS, O'Hollaren M. Chest 1999; 115(1):85.

STUDY OBJECTIVES: To validate three indicators of asthma severity as defined in the National Asthma Education Program (NAEP) guidelines (ie, frequency of symptoms, degree of airflow obstruction, and frequency of use of oral glucocorticoids), alone and in combination, against severity as assessed by pulmonary specialists provided with 24-month medical chart data. DESIGN: Cross-sectional comparison of questionnaire and clinical-based markers of asthma severity with physician-assessed severity based on chart review. The pulmonologists did not have access to the results of the baseline evaluations when making their severity assessments. SETTING AND PARTICIPANTS: Study participants were 193 asthmatic members (age range, 6 to 55 years) of a large health maintenance organization who underwent a baseline evaluation as part of a separate longitudinal study. This evaluation consisted of spirometry, skin prick testing, and a survey that included questions on symptoms and medication use. The participants in the ancillary study were selected, based on their baseline evaluation, to reflect a broad range of asthma severity. RESULTS: Based on the chart review, 86 of the study subjects (45%) had mild disease, 90 (45%) had moderate disease, and 17 (9%) had severe disease. This physician-assessed severity correlated highly ($p \leq 0.013$) with NAEP-based indices of severity based on oral glucocorticoid use (never, infrequently for attacks, frequently for attacks, and daily use) and on spirometry ($FEV_1 > 80\%$ predicted, 60 to 80% predicted, and $<60\%$ predicted). It did not, however, correlate with current asthma symptoms (≤ once/week, 2 to 6 times/week, daily) (p=0.87). A composite severity score based on spirometry and the glucocorticoid use data still provided an overall agreement of 63%, with a weighted kappa of 0.40. CONCLUSIONS: While current symptoms are the most important concern of patients with asthma, they reflect the current level of asthma control more than underlying disease severity. Investigators must therefore use caution when comparing groups of patients for whom severity categorization is based largely on symptomatology. This observation, that symptoms alone do not reflect disease severity, becomes even more important as health-care delivery moves closer to protocols/practice guidelines and 'best treatment' programs that rely heavily on symptoms to guide subsequent treatment decisions.

Portable Computerized Polysomnography in Attended and Unattended Settings—Mykytyn IJ, Sajkov D, Neill AM, McEvoy RD. Chest 1999;115(1):114.

STUDY OBJECTIVE: We compared the validity of a new portable polysomnographic recorder against a laboratory-based polysomnographic system from the same manufacturer. DESIGN AND PATIENTS: Simultaneous, full polysomnographic recordings from the portable device (PSGP) and the laboratory-based system (PSGL) were obtained using separate sets of sensors on 20 patients referred for investigation of sleep apnea. SETTING: After initial optimization of signals, the portable device was left unattended in 10 of the patients (to simulate home studies), while in the other 10 the signals were reviewed on a laptop computer screen and adjustments to electrode or sensor placement made as needed during the studies. Recordings were manually scored by a technologist blinded to the origin of the data. MEASUREMENTS AND RESULTS: The quality of signals was comparable between the PSGP and PSGL studies, apart from a slight decrease in respiratory signal quality during PSGP studies that led to reduced confidence in respiratory event scoring. S_{aO_2} signal loss was also greater in unattended PSGP. There was good agreement between PSGP and PSGL for sleep variables and the apnea-hypopnea index (r=0.99). The periodic limb movement index was slightly lower during unattended PSGP. Blinded physician assessment of the records led to a recommendation for repeat studies due to poor signal quality in one (10%) attended and one (10%) unattended portable recording. There was no significant discordance between PSGP and PSGL in the final diagnostic formulations. CONCLUSION: Portable polysomnography is a viable alternative to laboratory-based polysomnography and may be improved further by better sensor attachment.

Quality of Life in Patients with Obstructive Sleep Apnea: Effect of Nasal Continuous Positive Airway Pressure—A Prospective Study—D'Ambrosio C, Bowman T, Mohsenin V. Chest 1999;115(1):123.

BACKGROUND: Obstructive sleep apnea (OSA) is a common condition and is associated with excessive daytime sleepiness and neuropsychological dysfunction. There is limited evidence on the effect of OSA on the quality of life and its response to nasal continuous positive airway pressure (nCPAP) treatment. STUDY OBJECTIVE: To determine the effect of nCPAP on the quality of life in patients with OSA. DESIGN: Prospective determination of nCPAP effect in a case-series analysis. PATIENTS: We studied 29 patients (23 were male and 6 were female) with a mean (±SE) age of 4.4±2.3 years, a body mass index 36.3±2.0 kg/height m^2, and a diagnosis of OSA with respiratory disturbance index (RDI; apnea/hypopnea) of 77±9 events/h. MEASUREMENTS AND RESULTS: The quality of life was assessed by administering a Medical Outcomes Study Short Form-36 questionnaire before and after 8 weeks of nCPAP therapy in polysomnographically documented OSA. All dimensions of the quality of life were significantly impaired when compared with an age- and gender-matched population, expressed as a percentage of normative data: physical functioning, 75%; vitality, 41%; role functioning (physical, 54%; emotional, 61%; social, 66%); general health, 88%; and mental health, 76%. nCPAP therapy significantly improved the sleep-disordered breathing and sleep fragmentation. The nCPAP level for the group was 9.4±0.7 cm H_2O. Eight weeks of nCPAP therapy improved vitality (75%), social functioning (90%), and mental health (96%). The magnitude of improvement was related to the degree of quality of life impairment prior to treatment, rather than to the severity of disease as measured by the RDI and arousal indices. CONCLUSIONS: All aspects of the quality of life, from physical and emotional health to social functioning, are markedly impaired by OSA. nCPAP therapy improved those aspects related to vitality, social functioning, and mental health.

The Importance of Physical Fitness in the Performance of Adequate Cardiopulmonary Resuscitation—Lucia A, de las Heras JF, Perez M, Elvira JC, Carvajal A, Alvarez AJ, Chicharro JL. Chest 1999;115(1):158.

The aim of the present investigation was to evaluate the influence of the physical fitness of a cardiopulmonary resuscitation (CPR) provider on the performance of and physiologic response to CPR. To this end, comparisons were made of sedentary and physically active subjects in terms of CPR performance and physiologic variables. Two study groups were established: group P (n=14), composed of sedentary, professional CPR rescuers (mean [±SD]; age, 34±6 years; $\dot{V}_{O_2}$max, 32.5±5.5 mL/kg/min), and group Ex (n=14), composed of physically active, nonexperienced subjects (age, 34±6 years; $\dot{V}_{O_2}$max, 44.5±8.5 mL/kg/min). Each subject was re-

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quired to perform an 18-min CPR session, which involved manual external cardiac compressions (ECCs) on an electronic teaching mannequin following accepted standard CPR guidelines. Subjects' gas exchange parameters and heart rates (HRs) were monitored throughout the trial. Variables indicating the adequacy of the ECCs (ECC depth and the percentage of incorrect compressions and hand placements) also were determined. Overall CPR performance was similar in both groups. The indicators of ECC adequacy fell within accepted limits (ie, an ECC depth between 38 and 51 mm). However, fatigue prevented four subjects from group P from completing the trial. In contrast, the physiologic responses to CPR differed between groups. The indicators of the intensity of effort during the trial, such as HR or percentage of maximum oxygen uptake ($\dot{V}_{O_2}$max) were higher in group P subjects than group Ex subjects, respectively (HRs at the end of the trial, 139±22 vs 115±17 beats/min, $p < 0.01$; percentage of $\dot{V}_{O_2}$max after 12 min of CPR, 46.7±9.7% vs 37.2±10.4%, $p < 0.05$). These results suggest that a certain level of physical fitness may be beneficial to CPR providers to ensure the adequacy of chest compressions performed during relatively long periods of cardiac arrest.

Noninvasive Positive Pressure Ventilation: Successful Outcome in Patients with Acute Lung Injury/ARDS—Rocker GM, Mackenzie MG, Williams B, Logan PM. Chest 1999;115(1):173.

BACKGROUND: There is increasing support for the use of noninvasive positive pressure ventilation (NPPV) in the treatment of patients with acute respiratory failure. Highest success rates are recorded in patients with exacerbation of COPD, particularly in patients presenting primarily with hypercarbic respiratory failure. Success has been more limited in patients with acute hypoxemic respiratory failure, and there are few reports of NPPV in patients with acute lung injury (ALI) or ARDS. OBJECTIVES: We report the outcome of 12 episodes of ALI/ARDS in 10 patients treated with NPPV. DESIGN: Experiential cohort study. SETTING: Tertiary referral center and university hospital ICU. INTERVENTION: Provision of NPPV in patients with ALI/ARDS. RESULTS: Group median (range) APACHE (acute physiology and chronic health evaluation) II score was 16 (11 to 29). Success rate (avoidance of intubation and no further assisted ventilation for 72 h) was achieved on six of nine occasions (66%) when NPPV was used as the initial mode of assisted ventilation. It failed after three episodes of planned (1) or self (2) extubation. Duration of successful NPPV was 64.5 h (23.5 to 80.5 h) with ICU discharge in the next 24 to 48 h for three of six patients. Unsuccessful episodes lasted 7.3 h (0.1 to 116 h) with need for conventional ventilation for an additional 5 days (2.7 to 14 days). Survival (ICU and hospital) for the 10 patients was 70%. CONCLUSIONS: In a group of hemodynamically stable patients with severe ALI, NPPV had a high success rate. NPPV should be considered as a treatment option for patients in stable condition in the early phase of ALI/ARDS.

Degradation of Histamine Solutions used for Bronchoprovocation—Marshik P, Moghaddam S, Tebbett I, Hendeles L. Chest 1999;115(1):194.

STUDY OBJECTIVES: To determine optimal storage conditions for histamine diphosphate (HDP) solutions used for bronchoprovocation. DESIGN: HDP was dissolved in buffered saline solution to concentrations of 0.125 to 16 mg/mL and stored in 3-mL unit dose syringes at different temperatures for varying lengths of time, with and without protection from fluorescent light. SETTING: Dark freezer (-20 degrees C), dark refrigerator (4 degrees C), and laboratory counter top (20 degrees C) illuminated by fluorescent light (375 foot-candles). MEASUREMENTS: HDP concentrations were measured after the solutions were prepared and during storage by a high-performance liquid chromatographic assay that differentiates histamine from its break down products. RESULTS: All dilutions were sterile after preparation and contained 97 to 110% of the labeled amount of HDP. Solutions constantly exposed to fluorescent light (375 foot-candles) and room temperature (20 degrees C) contained only 20 to 37% of the initial concentrations after 7 days. The same dilutions stored at room temperature, but protected from light, contained 83 to 94% of the initial concentrations. Dilutions stored in the dark in a refrigerator (4 degrees C) retained 97% of the initial concentrations after 8 weeks, while dilutions stored in the dark freezer (-20 degrees C) were stable for 12 months. CONCLUSIONS: Exposure to fluorescent light at room temperature results in degradation of histamine solutions used for bronchoprovocation.

Dilutions stored in unit dose syringes and protected from light are stable for at least 8 weeks in the refrigerator and up to 12 months frozen. Once removed from the refrigerator or freezer, the solutions should be used within 6 h or discarded.

Catching Patients: Tuberculosis and Detention in the 1990s—Lerner BH. Chest 1999; 115(1):236.

The resurgence of tuberculosis (TB) in the early 1990s, including multidrug-resistant strains, led health officials to recommend the use of involuntary detention for persistently nonadherent patients. Using a series of recently published articles on the subject, this paper offers some opinions on how detention programs have balanced protection of the public's health with patients' civil liberties. Detained persons are more likely than other TB patients to come from socially disadvantaged groups. Health departments have generally used coercion appropriately, detaining patients as a last resort and providing them with due process. Yet health officials still retain great authority to bypass 'least restrictive alternatives' in certain cases and to detain noninfectious patients for months or years. Misbehavior within institutions may inappropriately be used as a marker of future nonadherence with medications. As rates of TB and attention to the disease again decline, forcible confinement of sick patients should be reserved for those persons who truly threaten the public's health.

Hemoptysis due to MDI Therapy in a Patient with Permanent Tracheostomy: Treatment with Mask AeroChamber—Newhouse MT. Chest 1999;115(1):279.

Persistent minor hemoptysis resulted from extensive granulation tissue on the main carina and adjacent bronchi due to frequent spraying of metered-dose inhaler (MDI)-generated aerosol medications directly into a permanent tracheostomy. Salbutamol, containing oleic acid, was considered the most likely cause. After an AeroChamber equipped with an infant mask was interposed between the MDI and the tracheal stoma, hemoptysis and the pathologic changes gradually resolved.

Tension Fecopneumothorax due to Colonic Perforation in a Diaphragmatic Hernia—Seelig MH, Klingler PJ, Schonleben K. Chest 1999;115(1):288.

A traumatic diaphragmatic hernia is a well-known complication following blunt abdominal or penetrating thoracic trauma. Although the majority of cases are diagnosed immediately, some patients may present later with a diaphragmatic hernia. A tension fecopneumothorax, however, is a rarity. We report on a patient who, 2 years after being treated for a stab wound to the chest, presented with an acute tension fecopneumothorax caused by the incarceration of the large bowel in the thoracic cavity after an intrathoracic perforation. The etiology and management of this condition are discussed.

Airway Obstruction Arising from Blood Clot: Three Reports and a Review of the Literature—Arney KL, Judson MA, Sahn SA. Chest 1999;115(1):293.

Airway obstruction due to presence of blood clot occurs in a variety of clinical settings; however, it is not always preceded by hemoptysis. The impact on respiratory function may be minimal or result in life-threatening ventilatory impairment. Three illustrative cases and a comprehensive literature review are presented. The presence of endobronchial blood clot is suggested by the clinical and radiographic findings of focal airway obstruction. The diagnosis is established by direct endoscopic evaluation. Initial efforts at removal of the airway clot, if warranted, involve lavage, suctioning, and forceps extraction through a flexible bronchoscope. If unsuccessful, further management options include rigid bronchoscopy, Fogarty catheter dislodgment of the clot, and topical thrombolytic agents.

Reduced Quality of Life in Survivors of Acute Respiratory Distress Syndrome Compared with Critically Ill Control Patients—Davidson TA, Caldwell ES, Curtis JR, Hudson LD, Steinberg KP. JAMA 1999;281(4):354.

CONTEXT: Health-related quality of life (HRQL) is reduced in patients who survive acute respiratory distress (ARDS), but whether this decline in HRQL is caused by ARDS or other aspects of the patient's illness or injury is unknown. OBJECTIVE: To determine if there are differences in the HRQL of ARDS survivors and comparably ill or injured controls without ARDS. DESIGN: Prospective, matched, parallel cohort study. SETTING: A 411-bed municipal medical and regional level I trauma center. PATIENTS: Seventy-three pairs of ARDS survivors and severity-matched controls with the clinical risk factors for ARDS of sepsis and trauma admitted between January 1, 1994, and July 30, 1996. MAIN OUTCOME MEASURES: The HRQL of ARDS survivors and controls, assessed by generic and pulmonary disease-specific HRQL instruments (Medical Outcomes Study 36-Item Short Form Health Survey, Standard Form [SF-36] and St George's Respiratory Questionnaire [SGRQ], respectively). RESULTS: Clinically meaningful and statistically significant reductions in HRQL scores of ARDS survivors ($n = 73$) were seen in 7 of 8 SF-36 domains and 3 of 3 SGRQ domains compared with matched controls ($P < 0.001$ for all reductions). The largest decrements in the HRQL were seen in physical function and pulmonary symptoms and limitations. Analysis of trauma-matched pairs ($n = 46$) revealed significant reductions in 7 of 8 SF-36 domains ($P \leq 0.02$) and 3 of 3 SGRQ domains ($P \leq 0.003$). Analysis of sepsis-matched pairs ($n = 27$) revealed significant reductions in 6 of 8 SF-36 domains ($P \leq 0.05$) and 3 of 3 SGRQ domains ($P \leq 0.002$). CONCLUSIONS: Survivors of ARDS have a clinically significant reduction in HRQL that appears to be caused exclusively by ARDS and its sequelae. Reductions were primarily noted in physical functioning and pulmonary disease-specific domains.

Effect of Ventilation Distribution on Aerosol Bolus Dispersion and Recovery—Brown JS, Gerrity TR, Bennett WD. J Appl Physiol 1998; 85(6):2112.

It has been speculated that convective ventilatory inhomogeneities are an important factor influencing aerosol bolus behavior in the compromised lung. Multiple-breath 133_{Xe} washout (MBWXe) is a commonly accepted test of ventilation distribution. By comparing aerosol bolus parameters to MBWXe in 9 healthy subjects and 14 cystic fibrosis patients with mild-to-moderate airway obstruction, we have attempted to discern the effect of altered ventilation distribution on aerosol bolus dispersion and recovery. Aerosol boluses (150-mL width) were delivered to the volumetric penetrations of 250 and 500 mL. Similar tidal volumes (approximately 1.25 liters) and flow rates (0.4 l/s) were used for aerosol bolus and MBWXe maneuvers. Associations between bolus parameters and ventilation distribution were only observed in the cystic fibrosis patients. We conclude that aerosol bolus dispersion and recovery are both influenced by convective ventilatory inhomogeneities induced by airway obstruction in these patients.

Association of Hypothyroidism and Obstructive Sleep Apnea—Kapur VK, Koepsell TD, deMaube J, Hert R, Sandblom RE, Psaty BM. Am J Respir Crit Care Med 1998;158(5 Pt 1): 1379.

Obstructive sleep apnea (OSA) and hypothyroidism are relatively common disorders that have similar clinical features and are thought to be causally linked. We sought to determine the prevalence of previously unrecognized hypothyroidism in a series of patients evaluated for OSA and whether an association between hypothyroidism and OSA was present. Chart review was used to obtain information on thyroid function status, polysomnography results, levothyroxine use, and clinical signs and symptoms in 336 consecutive adult patients who underwent polysomnography for suspected OSA. In addition, levothyroxine use was determined in age- and sex-matched control subjects for the

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purposes of a case-control study. Among the patients without prior history of hypothyroidism who underwent polysomnography and thyroid function testing, four new cases or 1. 41% (95% Cl 0.04-2.78) were found to have subclinical hypothyroidism. Our findings do not support routine thyroid screening by specialists in patients referred for polysomnography. The odds ratio of the association of prior history of hypothyroidism to OSA was 1.47 (95% Cl 0.8-2.8). Limitations in study design may have limited our ability to detect a statistically significant association between OSA and hypothyroidism.

Respiratory Resistive Impedance As an Index of Airway Obstruction during Nasal Continuous Positive Airway Pressure Titration—Lorino AM, Lofaso F, Duizabo D, Zerah F, Goldenberg F, d'Ortho MP, et al. Am J Respir Crit Care Med 1998;158(5 Pt 1):1465.

Esophageal pressure amplitude (ΔPes), inspiratory pulmonary resistance (RLI) and inspiratory flow limitation score (FS) are used as indices of upper airway obstruction for the titration of nasal continuous positive airway pressure (nCPAP) in patients with obstructive sleep apnea syndrome (OSAS). This study was designed to determine whether oscillatory respiratory resistive impedance at 16 Hz (RFO) might be proposed as an alternative index. Eleven OSAS patients were studied during a night of polysomnography-controlled nCPAP titration. Nasal flow ($\dot{V}$) and airway opening and esophageal pressures (Pao and Pes, respectively) were continuously measured during nasal breathing, and forced-flow oscillations (FO) were applied for 5 min at each nCPAP level. RLI was calculated by linear regression analysis of resistive pressure versus $\dot{V}$ over inspiration. RFO was obtained by linear regression analysis of respiratory resistive impedance versus frequency. Application of FO affected neither sleep nor pulmonary mechanics. RFO correlated with RLI in all patients. RFO did not correlate with DeltaPes in two patients, and was not significantly related to FS in five patients. This study demonstrates the applicability of the FO technique in sleeping patients receiving nCPAP, and the reliability of RFO for assessing pulmonary resistance. RFO might therefore be proposed as a quantitative index of airway obstruction for nCPAP titration.

Ventilatory Mechanics and Gas Exchange during Exercise before and after Lung Volume Reduction Surgery—Tschernko EM, Gruber EM, Jaksch P, Jandrasits O, Jantsch U, Brack T, et al. Am J Respir Crit Care Med 1998;158(5 Pt 1):1424.

Many patients with emphysema are able to meet ventilatory demands during resting conditions, but they show severe limitations during exercise. To examine the effect of lung volume reduction (LVR) surgery on exercise performance and the mechanism of possible improvement, we measured ventilatory mechanics (pulmonary resistance [RL], work of breathing [WOB], dynamic intrinsic positive end-expiratory pressure [PEEPi,dyn], peak expiratory flow rate [PEFR]), breathing pattern, oxygen uptake ($\dot{V}_{O_2}$), and carbon dioxide removal ($\dot{V}_{CO_2}$) at rest and during cycle ergometry in eight patients before and 3 mo after LVR surgery. Ventilatory mechanics were evaluated assessing esophageal pressure and air flow. Three months after LVR surgery, the tolerated workload was doubled when compared with the preoperative value ($p < 0.0005$), associated with a reduction of RL ($p < 0.05$), PEEPi,dyn ($p < 0.005$), and WOB ($p < 0.005$) at comparable workloads. Maximal ventilatory capacity and maximal tidal volume (V_T) increased significantly ($p < 0.01$). Maximal $\dot{V}_{O_2}$ increased from 474 ± 23 to 601 ± 16 mL/min ($p < 0.005$) and maximal $\dot{V}_{CO_2}$ from 401 ± 13 to 558 ± 21 mL/min ($p < 0.005$), though no significant difference at comparable workloads could be observed. In conclusion, emphysema surgery leads to an improvement of ventilatory mechanics at rest and during exercise. Higher maximal VT and minute ventilation were observed, resulting in improvement of maximal $\dot{V}_{O_2}$ and $\dot{V}_{CO_2}$ and exercise capacity.

Current Status of Long Term Ventilation of Children in the United Kingdom: Questionnaire Survey—Jardine E, O'Toole M, Paton JY, Wallis C. BMJ 1999;318(7179):295.

Objectives: To identify the number and current location of children, aged 0 to 16 years, requiring long term ventilation in the United Kingdom, and to establish their underlying diagnoses and ventilatory needs. Design: Postal questionnaires sent to consultant respiratory paediatricians and all lead clinicians of intensive care and special care baby units in the United Kingdom. Subjects: All children in the United Kingdom who, when medically stable, continue to need a mechanical aid for breathing. Results: 141 children requiring long term ventilation were identified from the initial questionnaire. Detailed information was then obtained on 136 children from 30 units. Thirty three children (24%) required continuous positive pressure ventilation by tracheostomy over 24 hours, and 103 received ventilation when asleep by a non-invasive mask (n=62; 46%), tracheostomy (n=32; 24%), or negative pressure ventilation (n=9; 7%). Underlying conditions included neuromuscular disease (n=62; 46%), congenital central hypoventilation syndrome (n=18; 13%), spinal injury (n=16; 12%), craniofacial syndromes (n=9; 7%), bronchopulmonary dysplasia (n=6; 4%), and others (n=25; 18%). 93 children were cared for at home. 43 children remained in hospital because of home circumstances, inadequate funding, or lack of provision of home carers. 96 children were of school age and 43 were attending mainstream school. Conclusions: A significant increase in the number of children requiring long term ventilation in the United Kingdom has occurred over the past decade. Contributing factors include improved technology, developments in paediatric non-invasive ventilatory support, and a change in attitude towards home care. Successful discharge home and return to school is occurring even for severely disabled patients. Funding and home carers are common obstacles to discharge.

Derivation of a Clinical Decision Rule for the Discontinuation of In-Hospital Cardiac Arrest Resuscitations—van Walraven C, Forster AJ, Stiell IG. Arch Intern Med 1999;159(2):129.

BACKGROUND: Most patients undergoing in-hospital cardiac resuscitation will not survive to hospital discharge. OBJECTIVE: To derive a decision rule permitting the discontinuation of futile resuscitation attempts by identifying patients with no chance of surviving to hospital discharge. PATIENTS AND METHODS: Patient, arrest, and outcome data for 1077 adult patients undergoing in-hospital cardiac resuscitation was retrieved from 2 randomized clinical trials involving 5 teaching hospitals at 2 university centers. Recursive partitioning was used to identify a decision rule using variables significantly associated with death in hospital. RESULTS: One hundred three patients (9.6%) survived to hospital discharge. Death in hospital was significantly more likely if patients were older than 75 years ($P<0.001$), the arrest was unwitnessed ($P = 0.003$), the resuscitation lasted longer than 10 minutes ($P<0.001$), and the initial cardiac rhythm was not ventricular tachycardia or fibrillation ($P<0.001$). All patients died if there was no pulse 10 minutes after the start of cardiopulmonary resuscitation, the initial cardiac rhythm was not ventricular tachycardia or fibrillation, and the arrest was not witnessed. As a resuscitation rule, these parameters identified all patients who survived to hospital discharge (sensitivity, 100%; 95% confidence interval, 97.1%-100%). Resuscitation could have been discontinued for 119 (12.1%) of 974 patients who did not survive, thereby avoiding 47 days of postresuscitative care. CONCLUSIONS: A practical and highly sensitive decision rule has been derived that identifies patients with no chance of surviving in-hospital cardiac arrest. Prospective validation of the rule is necessary before it can be used clinically.

Differences Between Asthma Exacerbations and Poor Asthma Control—Reddel H, Ware S, Marks G, Salome C, Jenkins C, Woolcock A. Lancet 1999;353(9150):364.

BACKGROUND: Increased variation in peak expiratory flow (PEF) is characteristic of poorly controlled asthma, and measurement of diurnal variability of PEF has been recommended for assessment of asthma severity, including during exacerbations. We aimed to test whether asthma exacerbations had the same PEF characteristics as poor asthma control. METHODS: Electronic PEF records from 43 patients with initially poorly controlled asthma were examined for all exacerbations that occurred after PEF reached a plateau with inhaled corticosteroid treatment. Diurnal variability of PEF was compared during exacerbations, run-in (poor asthma control), and the period of stable asthma before each exacerbation. FINDINGS: Diurnal variability was 21.3% during poor asthma control and improved to 5.3% (stable asthma) with inhaled corticosteroid treatment. 40 exacerbations occurred in 26 patients over 2–16 months; 38 (95%) of exacerbations were associated with symptoms of clinical respiratory infection. During exacerbations, consecutive PEF values fell linearly over several days then improved linearly. However, diurnal variability during exacerbations (7.7%) was not significantly higher than during stable asthma (5.4%, $p=0.1$). PEF data were consistent with impaired response to inhaled β2-agonist during exacerbations but not during poorly controlled asthma. INTERPRETATION: Asthmatics remain vulnerable to exacerbations during clinical respiratory infections, even after asthma is brought under control. Calculation of diurnal variability may fail to detect important changes in lung function. PEF variation is strikingly different during exacerbations compared with poor asthma control, suggesting differences in β2-adrenoceptor function between these conditions.

Continuous Cardiac Output and Mixed Venous Oxygen Saturation Monitoring—Cariou A, Monchi M, Dhainaut JF. J Crit Care 1998; 13(4):198.

Continuous assessment of cardiac output and SvO_2 in the critically ill may be helpful in both the monitoring variations in the patient's cardiovascular state and in determining the efficacy of therapy. Commercially available continuous cardiac output (CCO) monitoring systems are based on the pulsed warm thermodilution technique. In vitro validation studies have demonstrated that this method provides higher accuracy and greater resistance to thermal noise than standard bolus thermodilution techniques. Numerous clinical studies comparing bolus with continuous thermodilution techniques have shown this technique similarly accurate to track each other and to have negligible bias between them. The comparison between continuous thermal and other cardiac output methods also demonstrates good precision of the continuous thermal technique. Accuracy of continuous oximetry monitoring using reflectance oximetry via fiberoptics has been assessed both in vitro and in vivo. Most of the studies testing agreement between continuous SvO_2 measurements and pulmonary arterial blood samples measured by standard oximetry have shown good correlation. Continuous SvO_2 monitoring is often used in the management of critically ill patients. The most recently designed pulmonary artery catheters are now able to simultaneously measure either SvO_2 and CCO or SvO_2 and right ventricular ejection fraction. This ability to view simultaneous trends of SvO_2 and right ventricular performance parameters will probably allow the clinician to graphically see the impact of volume loading or inotropic therapy over time, as well as the influence of multiple factors, including right ventricular dysfunction, on SVO_2. However, the cost-effectiveness of new pulmonary artery catheters application remains still questionable because no established utility or therapeutic guidelines are available.

Clinical Trial of An Ex Vivo Arterial Blood Gas Monitor—McKinley BA, Parmley CL. J Crit Care 1998;13(4):190.

PURPOSE: The purpose of this study was to test the performance of a patient attached, on demand ex vivo arterial blood gas (ABG) monitor, and to compare the frequency of ABG analysis using the monitor, where the monitor was operated by intensive care unit (ICU) staff on shock trauma and neurosurgical intensive care patients for $\leq$ 6 days, with standard clinical laboratory analysis. MATERIALS AND METHODS: The ABG monitor (SensiCath; Optical Sensors Inc., Minneapolis, MN) incorporates fiber optic pH, PCO_2, PO_2, and thermistor temperature sensors in a 0.3-mL sensor chamber that attaches in line with the patient's arterial pressure tubing and connects via a fiberoptic cable to a bedside instrument. The monitor and standard clinical laboratory performance were compared following an institutionally approved protocol. Adult ICU patients ($n = 30$) were studied for whom an arterial cannula was required, the expected ICU stay was $>$ 72 hours, $\geq$ 2 ABG analyses/day were anticipated, and informed consent had been obtained. Paired comparison ABG analyses and quality assurance checks were performed daily. The frequency of ABG analyses in this study, for which monitor values were used for clinical decision making, was compared with the frequency previously reported for the same ICUs, for which the monitor and laboratory results were compared but only the latter were used for clinical decision making. RESULTS: Five hundred ABG analyses, 436 over the first 72 hours, were obtained using the monitor for patient management over 3,248 patient hours (85 ± 47 hours/patient). Monitor-laboratory comparison ABG analyses ($n = 258$) indicated stable performance over 6 days: For pH, the range of laboratory measurements was 7.200 to 7.540, accuracy (mean difference between monitor and laboratory measurement) was +0.013, and precision (standard deviation of difference between monitor and laboratory measurements) was ±0.031. For PCO_2, range: 18 to 78.5, accuracy: -0.8, precision: ±3.4 mm Hg. For PO_2, range: 41.0 to 344.0, accuracy: +2.3, precision: ±12.8 mm Hg. The frequency of ABG analyses obtained using the monitor (ie, 15.0 ± 11.6 ABGs/patient/72 hours) was significantly greater than that using the clinical laboratory (ie, 8.8 ± 4.2 ABGs/patient/72 hours) ($P = .01$). CONCLUSION: The ABG monitor provides performance comparable to standard clinical laboratory analysis for $\leq$ 6 days ($\leq$ 144 hours), consistent with ICU arterial cannula changeout schedules. More frequent ABG analyses are obtained by critical care practitioners using the monitor compared with the clinical laboratory system, suggesting that clinical decision making based on ABG data may be limited by the frequency of ABG analysis.

Prolonged Severe Hypercapnia Complicating Near Fatal Asthma in a 35-Year-Old Woman—Adnet F, Plaisance P, Borron SW, Levy A, Payen D. Intensive Care Med 1998; 24(12):1335.

OBJECTIVE: We describe a patient with a prolonged and severe hypercapnia occurring during an episode of status asthmaticus induced by ophthalmic instillation of carteolol. SETTING: Prehospital Emergency Medical Service and Pulmonary Intensive Care Unit in a university hospital. PATIENT: A 35-year-old female developed an acute asthma attack while at home, which required advanced life support. INTERVENTION: On hospital admission, arterial blood gases revealed a P_{aCO_2} of 208 mmHg. Hypercapnia persisted with a P_{aCO_2} of more than 190 mmHg for 10 h, with pH always less than 7.00. The patient was finally discharged after 26 days without sequelae. CONCLUSION: This case illustrates the cerebral and cardiovascular tolerance of severe and prolonged hypercapnia associated with major acidosis.

Use of Continuous Bispectral EEG Monitoring to Assess Depth of Sedation in ICU Patients—De Deyne C, Struys M, Decruyenaere J, Creupelandt J, Hoste E, Colardyn F. Intensive Care Med 1998;24(12):1294.

Monitoring the depth of sedation in patients under intensive care is difficult. Clinical assessment by the different scoring systems produces insufficient information, especially once deeply sedated patients become unresponsive to any external stimulation. Recently, the bispectral index (BIS), the result of computerized bispectral electroencephalographic monitoring, was found to be the best predictor of depth of anaesthesia during surgical intervention. This report concerns BIS monitoring in 18 randomly selected, deeply sedated, surgical patients in the intensive care unit, who were unresponsive to standard clinical stimulation (Ramsay sedation score). A wide range of BIS was observed, with 15 of the patients having a BIS below 60, indicating a state of deep sedation (or possibly over-sedation). Therefore, further studies using BIS monitoring in patients under intensive care are needed to determine if this method can guide sedation and prevent oversedation in this context and, most importantly, to analyse its final cost-benefit ratio.

Changes in Pulmonary Mechanics After Fiberoptic Bronchoalveolar Lavage in Mechanically Ventilated Patients—Klein U, Karzai W, Zimmermann P, Hannemann U, Koschel U, Brunner JX, Remde H. Intensive Care Med 1998;24(12):1289.

OBJECTIVE: We prospectively assessed the impact of bronchoalveolar lavage (BAL) on respiratory mechanics in critically ill, mechanically ventilated patients. STUDY DESIGN: Mechanically ventilated patients underwent BAL of one lung segment using 5 x 20 mL of sterile, physiologic saline with a temperature of 25–28 degrees C. The fractional inspired oxygen was increased to 1.0, but ventilator settings were otherwise left unchanged. Static pulmonary compliance, pulmonary resistance, alveolar ventilation, and serial dead space were measured 60 min and 2 min before and 8, 60, and 180 min after BAL to assess the consequences of the procedure. In addition, blood gases [partial pressure of carbon dioxide in arterial blood (P_{aCO_2}) and arterial oxigen tension (P_{aO_2})], hemodynamic variables (heart rate, systolic and diastolic blood pressure), and body temperature were recorded at the same time points. SETTING: Intensive care unit of a university hospital. PATIENTS: 18 consecutive critically ill, mechanically ventilated patients. RESULTS: Pulmonary compliance decreased by 23% ($p < 0.05$) and pulmonary resistance increased by 22% ($p < 0.05$) shortly after BAL. The changes in pulmonary compliance and resistance were more than 30% in one third of the patient population. One hour after the procedure, P_{aO_2} was significantly lower and P_{aCO_2} significantly higher than before the procedure. Three hours after the procedure, pulmonary resistance returned to pre-BAL values but compliance remained 10% below baseline values ($p < 0.05$). CONCLUSION: BAL in mechanically ventilated patients is associated with deterioration of pulmonary mechanics and function.

For COPD a Combination of Ipratropium Bromide and Albuterol Sulfate Is More Effective than Albuterol Base—Campbell S. Arch Intern Med 1999;159(2):156.

BACKGROUND: A combination metered-dose inhaler aerosol containing ipratropium bromide and albuterol sulfate has been reported to be more effective than either of its components in patients with chronic obstructive pulmonary disease. The dose of albuterol sulfate is equal in moles per liter to the dose of albuterol base used in the commercially available metered-dose inhalers. OBJECTIVE: To compare the safety and efficacy of the combination of ipratropium bromide and albuterol sulfate with a commonly prescribed albuterol metered-dose inhaler containing albuterol base alone. METHODS: Investigators at different sites performed a double-blind, 29-day trial involving 357 patients with chronic obstructive pulmonary disease. Efficacy measurements were taken at 15, 30, and 60 minutes after treatment with study medication and then hourly up to 6 hours on days 1 and 29 of the trial. The primary end point was improvement in forced expiratory volume in 1 second. Clinical status was followed up and safety monitoring was also performed. RESULTS: The combination produced a significantly greater peak and mean improvement in forced expiratory volume in 1 second over albuterol base alone on both test days. Similar changes were seen with forced vital capacity. Evaluations of clinical status were better for patients receiving combination therapy, and some improvements were statistically significant. The overall incidence of adverse effects was similar in the 2 treatment groups. CONCLUSION: We conclude that a combination of ipratropium bromide and albuterol sulfate is more effective at improving pulmonary function than albuterol base alone, with no potentiation of adverse effects.

The Effect of High-Dose Inhaled Beclomethasone Dipropionate in Patients with Stable COPD—Nishimura K, Koyama H, Ikeda A, Tsukino M, Hajiro T, Mishima M, Izumi T. Chest 1999;115(1):31.

BACKGROUND: The benefits of inhaled corticosteroids in the management of COPD are less apparent than they are in asthma therapy, and the potential for adverse systemic effects of high-dose inhaled corticosteroids has been recognized recently. It is therefore essential to know the maximal obtainable benefits in order to assess the risk/benefit ratio of this treatment. PURPOSE: The aim of this study was to investigate the maximal obtainable benefits of high-dose inhaled corticosteroids, 3 mg/d of beclomethasone dipropionate (BDP), when used in combination with adequate doses of regular bronchodilators in patients with stable COPD. STUDY DESIGN: Thirty patients with stable COPD completed a randomized, double-blind, placebo-controlled cross-over trial with either 3 mg/d of BDP or with a matching placebo using a metered-dose inhaler with a spacer device for 4 weeks during each treatment period. All of the patients continued to inhale both 400 microg of salbutamol qid and 80 microg of ipratropium bromide qid. RESULTS: The mean prebronchodilator FEV_1 was 0.97±0.35 L during the placebo period and 1.08±0.38 L during the BDP period ($p < 0.001$). While on BDP, five patients demonstrated a response in their FEV_1 of more than 8.5% of the predicted value, which was above the range that covered 95% of the distribution of the placebo response. The mean absolute improvement in the FEV_1 in these 5 objective responders was 0.34±0.10 L, compared to 0.06±0.09 L in the 25 objective nonresponders. Symptom scores for wheezing and dyspnea were significantly better with BDP than with placebo. Hoarseness and sore throat were associated more with BDP treatment. CONCLUSION: Although a considerable minority of patients benefited substantially from this treatment, the overall outcome does not seem to justify the widespread use of this treatment in the light of increasing recognition of the potential adverse systemic effects of high-dose inhaled corticosteroids. *See the related editorial: Steroids in COPD: The Nearly Eternal Question—Anthonisen NR. Chest 1999;115(1):3–4.*

Theophylline for Irreversible Chronic Airflow Limitation: A Randomized Study Comparing n of 1 Trials to Standard Practice—Mahon JL, Laupacis A, Hodder RV, McKim DA, Paterson NA, Wood TE, Donner A. Chest 1999;115(1):38.

STUDY OBJECTIVE: To compare quality of life and exercise capacity (primary aim), and drug usage (secondary aim), between groups of patients with irreversible chronic airflow limitation (CAL) who were undergoing theophylline (Theo-Dur; Key Pharmaceuticals; Kenilworth, NJ) therapy guided by n of 1 trials or standard practice. DESIGN: Randomized study of n of 1 trials vs standard practice. SETTING: Outpatient departments in two tertiary care centers. PATIENTS: Sixty-eight patients with irreversible CAL who were symptomatic despite the use of inhaled bronchodilators, and who were unsure whether theophylline was helping them following open treatment, were randomized into n of 1 trials (N=34) or standard practice. INTERVENTIONS: The n of 1 trials (single-patient, randomized, double-blind, multiple crossover comparisons of the effect on dyspnea of theophylline vs a placebo) followed published guidelines. Standard practice patients stopped taking theophylline but resumed it if their dyspnea worsened. If their dyspnea then improved, theophylline was continued. In both groups, a decision about continuing or stopping the use of theophylline was made within 3 months of randomization. MEASUREMENTS AND RESULTS: The primary outcomes (the chronic respiratory disease questionnaire [CRQ] and 6-min walk) were measured at baseline, 6 months, and 12 months by personnel blinded to treatment group allocation. No between-group differences (n of 1 minus standard practice) were seen in within-group changes over time (1 year

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minus baseline) in the CRQ Physical Function score (point estimate on the difference, -2.8; 95% confidence limits [CLs], -8.2, 2.5), CRQ Emotional Function score (point estimate on the difference, 0.5; 95% CLs, -4.7, 5.7), or 6-min walk (point estimate on the difference, 8 m; 95% CLs, -26, 44 m). No differences between groups were seen in the secondary outcome of the proportion of patients taking theophylline at 6 and 12 months. In 7 of 34 n of 1 trial patients (21%), dyspnea improved during theophylline treatment compared with placebo treatment. CONCLUSIONS: Using n of 1 trials to guide theophylline therapy in patients with irreversible CAL did not improve their quality of life or exercise capacity, or reduce drug usage, over 1 year compared to standard practice. Under the objective conditions of an n of 1 trial, 21% of patients with CAL responded to theophylline. There remains a rationale for considering theophylline in patients with irreversible CAL who remain symptomatic despite the use of inhaled bronchodilators, but the use of n of 1 trials to guide this decision did not yield clinically important advantages over standard practice.

Lung Volumes in 4,774 Patients with Obstructive Lung Disease—Dykstra BJ, Scanlon PD, Kester MM, Beck KC, Enright PL. Chest 1999;115(1):68.

STUDY OBJECTIVES: To determine the correlates of static lung volumes in patients with airways obstruction, and to determine if static lung volumes differ between asthma and COPD. PATIENTS AND METHODS: We examined the data from all of the adult patients (mean age of 69) who were referred to a pulmonary function laboratory from January 1990 through July 1994 with an FEV_1/FVC ratio of < 0.70 and tested using a body plethysmograph. Correlates were determined using regression analysis. MEASUREMENTS AND RESULTS: Of the 4,774 patients observed with evidence of airways obstruction, 61% were men. Self-reported diagnoses included asthma, 19%; emphysema or COPD, 23%; chronic bronchitis, 1.5%; and alpha1-antiprotease deficiency, 0.6%. Fifty-six percent of the patients did not report a respiratory disease. The degree of hyperinflation, as determined by the residual volume (RV)/total lung capacity (TLC) ratio, or the RV % predicted (but not the TLC % predicted), was strongly associated with the degree of airways obstruction (the FEV_1 % predicted). Patients with moderate to severe airways obstruction and high RV and TLC levels were more likely to have COPD than asthma. Of the 1,872 patients with a reduced vital capacity determined by spirometry testing, 87% had hyperinflation as defined by the RV/TLC, and 9.5% had a low TLC (with less severe airways obstruction). CONCLUSION: In patients found to have airways obstruction by spirometry, the additional measurement of static lung volumes added little to the clinical interpretation.

Comparison of 2.5 vs 7.5 mg of Inhaled Albuterol in the Treatment of Acute Asthma—Emerman CL, Cydulka RK, McFadden ER. Chest 1999;115(1):92.

PURPOSE: The optimal dose of albuterol to use in the treatment of acute asthma has yet to be established. The National Asthma Education and Prevention Program (NAEPP) recommends a starting dose of 2.5 to 5 mg of aerosolized albuterol every 20 min, although European authorities recommend higher doses. The purpose of this study was to compare 2.5 vs 7.5 mg of nebulized albuterol for the treatment of acute asthma. SUBJECTS: We studied 160 patients presenting to the emergency department with acute asthma. METHODS: On enrollment, patients underwent baseline testing, including initial spirometry. All patients received prednisone, 60 mg, orally. Patients then received in a randomized, double-blinded fashion, nebulized albuterol either 2.5 or 7.5 mg every 20 min for a total of three doses. Spirometry was repeated after each of the first two treatments and again 40 min after completion of the three treatments. RESULTS: The pretreatment FEV_1 was 36.9±16.6% of predicted normal in the low-dose group vs 41.5±15.4% of predicted normal in the high-dose group (not significant [NS]). The patients in the low-dose group had a 50.3±62.6% improvement in FEV_1 pretreatment to post-treatment, whereas those in the high-dose group had a 44.6±48.2% improvement in FEV_1 (NS). There was no difference in the admission rate in the low-dose group (43%) as compared with that of the high-dose group (39%; NS). CONCLUSION: We conclude that there is no advantage to the routine administration of doses of albuterol higher than 2.5 mg every 20 min. It is possible that there may be an advantage in the most severely obstructed patients, although this study did not enroll enough patients with very severe asthma to evaluate this. As has been previously demonstrated, patients who subsequently require admission have a diminished response to albuterol. This decreased responsiveness is seen with the first aerosol administration and is unaffected by increasing the dose.

Portable Computerized Polysomnography in Attended and Unattended Settings—Mykytyn IJ, Sajkov D, Neill AM, McEvoy RD. Chest 1999;115(1):114.

STUDY OBJECTIVE: We compared the validity of a new portable polysomnographic recorder against a laboratory-based polysomnographic system from the same manufacturer. DESIGN AND PATIENTS: Simultaneous, full polysomnographic recordings from the portable device (PSGP) and the laboratory-based system (PSGL) were obtained using separate sets of sensors on 20 patients referred for investigation of sleep apnea. SETTING: After initial optimization of signals, the portable device was left unattended in 10 of the patients (to simulate home studies), while in the other 10 the signals were reviewed on a laptop computer screen and adjustments to electrode or sensor placement made as needed during the studies. Recordings were manually scored by a technologist blinded to the origin of the data. MEASUREMENTS AND RESULTS: The quality of signals was comparable between the PSGP and PSGL studies, apart from a slight decrease in respiratory signal quality during PSGP studies that led to reduced confidence in respiratory event scoring. S_{aO_2} signal loss was also greater in unattended PSGP. There was good agreement between PSGP and PSGL for sleep variables and the apnea-hypopnea index (r=0.99). The periodic limb movement index was slightly lower during unattended PSGP. Blinded physician assessment of the records led to a recommendation for repeat studies due to poor signal quality in one (10%) attended and one (10%) unattended portable recording. There was no significant discordance between PSGP and PSGL in the final diagnostic formulations. CONCLUSION: Portable polysomnography is a viable alternative to laboratory-based polysomnography and may be improved further by better sensor attachment. *See the related editorial: **Full Polysomnography in the Home: Has It Come of Age?**—Millman RP. Chest 1999; 115(1):6–7.*

The Importance of Physical Fitness in the Performance of Adequate Cardiopulmonary Resuscitation—Lucia A, de las Heras JF, Perez M, Elvira JC, Carvajal A, Alvarez AJ, Chicharro JL. Chest 1999;115(1):158.

The aim of the present investigation was to evaluate the influence of the physical fitness of a cardiopulmonary resuscitation (CPR) provider on the performance of and physiologic response to CPR. To this end, comparisons were made of sedentary and physically active subjects in terms of CPR performance and physiologic variables. Two study groups were established: group P (n=14), composed of sedentary, professional CPR rescuers (mean [±SD]; age, 34±6 years; VO_2max, 32.5±5.5 mL/kg/min), and group Ex (n=14), composed of physically active, nonexperienced subjects (age, 34±6 years; VO_2max, 44.5±8.5 mL/kg/min). Each subject was required to perform an 18-min CPR session, which involved manual external cardiac compressions (ECCs) on an electronic teaching mannequin following accepted standard CPR guidelines. Subjects' gas exchange parameters and heart rates (HRs) were monitored throughout the trial. Variables indicating the adequacy of the ECCs (ECC depth and the percentage of incorrect compressions and hand placements) also were determined. Overall CPR performance was simi-

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lar in both groups. The indicators of ECC adequacy fell within accepted limits (ie, an ECC depth between 38 and 51 mm). However, fatigue prevented four subjects from group P from completing the trial. In contrast, the physiologic responses to CPR differed between groups. The indicators of the intensity of effort during the trial, such as HR or percentage of maximum oxygen uptake (VO_2max) were higher in group P subjects than group Ex subjects, respectively (HRs at the end of the trial, 139±22 vs 115±17 beats/min, $p < 0.01$; percentage of VO_2max after 12 min of CPR, 46.7±9.7% vs 37.2±10.4%, $p < 0.05$). These results suggest that a certain level of physical fitness may be beneficial to CPR providers to ensure the adequacy of chest compressions performed during relatively long periods of cardiac arrest.

Catching Patients: Tuberculosis and Detention in the 1990s—Lerner BH. Chest 1999; 115(1):236.

The resurgence of tuberculosis (TB) in the early 1990s, including multidrug-resistant strains, led health officials to recommend the use of involuntary detention for persistently nonadherent patients. Using a series of recently published articles on the subject, this paper offers some opinions on how detention programs have balanced protection of the public's health with patients' civil liberties. Detained persons are more likely than other TB patients to come from socially disadvantaged groups. Health departments have generally used coercion appropriately, detaining patients as a last resort and providing them with due process. Yet health officials still retain great authority to bypass "least restrictive alternatives" in certain cases and to detain noninfectious patients for months or years. Misbehavior within institutions may inappropriately be used as a marker of future nonadherence with medications. As rates of TB and attention to the disease again decline, forcible confinement of sick patients should be reserved for those persons who truly threaten the public's health.

Hemoptysis due to MDI Therapy in a Patient with Permanent Tracheostomy: Treatment with Mask AeroChamber—Newhouse MT. Chest 1999;115(1):279.

Persistent minor hemoptysis resulted from extensive granulation tissue on the main carina and adjacent bronchi due to frequent spraying of metered-dose inhaler (MDI)-generated aerosol medications directly into a permanent tracheostomy. Salbutamol, containing oleic acid, was considered the most likely cause. After an AeroChamber equipped with an infant mask was interposed between the MDI and the tracheal stoma, hemoptysis and the pathologic changes gradually resolved.

Comparison of Lifestyle and Structured Interventions To Increase Physical Activity and Cardiorespiratory Fitness: A Randomized Trial—Dunn AL, Marcus BH, Kampert JB, Garcia ME, Kohl HW 3rd, Blair SN. JAMA 1999;281(4):327.

CONTEXT: Even though the strong association between physical inactivity and ill health is well documented, 60% of the population is inadequately active or completely inactive. Traditional methods of prescribing exercise have not proven effective for increasing and maintaining a program of regular physical activity. OBJECTIVE: To compare the 24-month intervention effects of a lifestyle physical activity program with traditional structured exercise on improving physical activity, cardiorespiratory fitness, and cardiovascular disease risk factors. DESIGN: Randomized clinical trial conducted from August 1, 1993, through July 31, 1997. PARTICIPANTS: Sedentary men ($n = 116$) and women ($n = 119$) with self-reported physical activity of less than 36 and 34 kcal/kg per day, respectively. INTERVENTIONS: Six months of intensive and 18 months of maintenance intervention on either a lifestyle physical activity or a traditional structured exercise program. MAIN OUTCOME MEASURES: Primary outcomes were physical activity assessed by the 7-Day Physical Activity Recall and peak oxygen consumption (VO_2peak) by a maximal exercise treadmill test. Secondary outcomes were plasma lipid and lipoprotein cholesterol concentrations, blood pressure, and body composition. All measures were obtained at baseline and at 6 and 24 months. RESULTS: Both the lifestyle and structured activity groups had significant and comparable improvements in physical activity and cardiorespiratory fitness from baseline to 24 months. Adjusted mean changes (95% confidence intervals [CIs]) were 0.84 (95% CI, 0.42–1.25 kcal/kg per day; $P< 0.001$) and 0.69 (95% CI, 0.25–1.12 kcal/kg day; $P = 0.002$) for activity, and 0.77 (95% CI, 0.18–1.36 mL/kg per minute; $P = 0.01$) and 1.34 (95% CI, 0.72–1.96 mL/kg per minute; $P< 0.001$) for VO_2peak for the lifestyle and structured activity groups, respectively. There were significant and comparable reductions in systolic blood pressure (-3.63 [95% CI, -5.54 to -1.72 mm Hg; $P< 0.001$] and -3.26 [95% CI, -5.26 to -1.25 mm Hg; $P = 0.002$]) and diastolic blood pressure (-5.38 [95% CI, -6.90 to -3.86 mm Hg; $P< 0.001$] and -5.14 [95% CI, -6.73 to -3.54 mm Hg; $P< 0.001$) for the lifestyle and structured activity groups, respectively. Neither group significantly changed their weight (-0.05 [95% CI, -1.05 to 0.96 kg; $P = 0.93$] and 0.69 [95% CI, -0.37 to 1.74 kg; $P = 0.20$]), but each group significantly reduced their percentage of body fat (-2.39% [95% CI, -2.92% to -1.85%; $P< 0.001$] and -1.85% [95% CI, -2.41% to -1.28%; $P< 0.001$]) in the lifestyle and structured activity groups, respectively. CONCLUSIONS: In previously sedentary healthy adults, a lifestyle physical activity intervention is as effective as a structured exercise program in improving physical activity, cardiorespiratory fitness, and blood pressure. *See the related editorial: **Benefits of Lifestyle Activity vs Structured Exercise**—Pratt M. JAMA 1999;281(4):375–376.*

Noninfectious Lung Disease in Immunocompromised Patients—Conces DJ Jr. J Thorac Imaging 1999;14(1):9.

Immunocompromised hosts have defects in their immune system that make them at risk of developing a variety of infections. In addition, these persons may develop a wide variety of noninfectious disease processes that involve the lung. These disorders may be caused by the underlying disease process. This may be seen with the development of metastatic disease from the underlying neoplasm, or it may represent the development of a malignancy secondary to therapy, as is seen with posttransplant lymphoproliferative disease. The abnormalities may be a result of the therapy used to treat the patients, as is seen with radiation injury to the lung and drug toxicity. Pulmonary edema may occur and be from a wide variety of causes. All of these disease processes may simulate an infectious process and must be differentiated from infection to allow proper therapeutic intervention.

Pulmonary Disease in the Immunocompromised Child—Pennington DJ, Lonergan GJ, Benya EC. J Thorac Imaging 1999;14(1):37.

Immune deficiency states in children may be related to primary immunodeficiency syndromes or secondary disorders of the immune system. The secondary immunodeficiencies in children include human immunodeficiency virus-associated acquired immunodeficiency, as well as immunosuppression secondary to antineoplastic chemotherapeutic agents, bone marrow transplantation, and drugs given to prevent transplant rejection. This article discusses the common primary and secondary immunocompromised states of childhood, with emphasis on their attendant infectious, lymphoproliferative, and neoplastic complications.

Opportunistic Fungal Pneumonia—Connolly JE Jr, McAdams HP, Erasmus JJ, Rosado-de-Christenson ML. J Thorac Imaging 1999;14(1): 51.

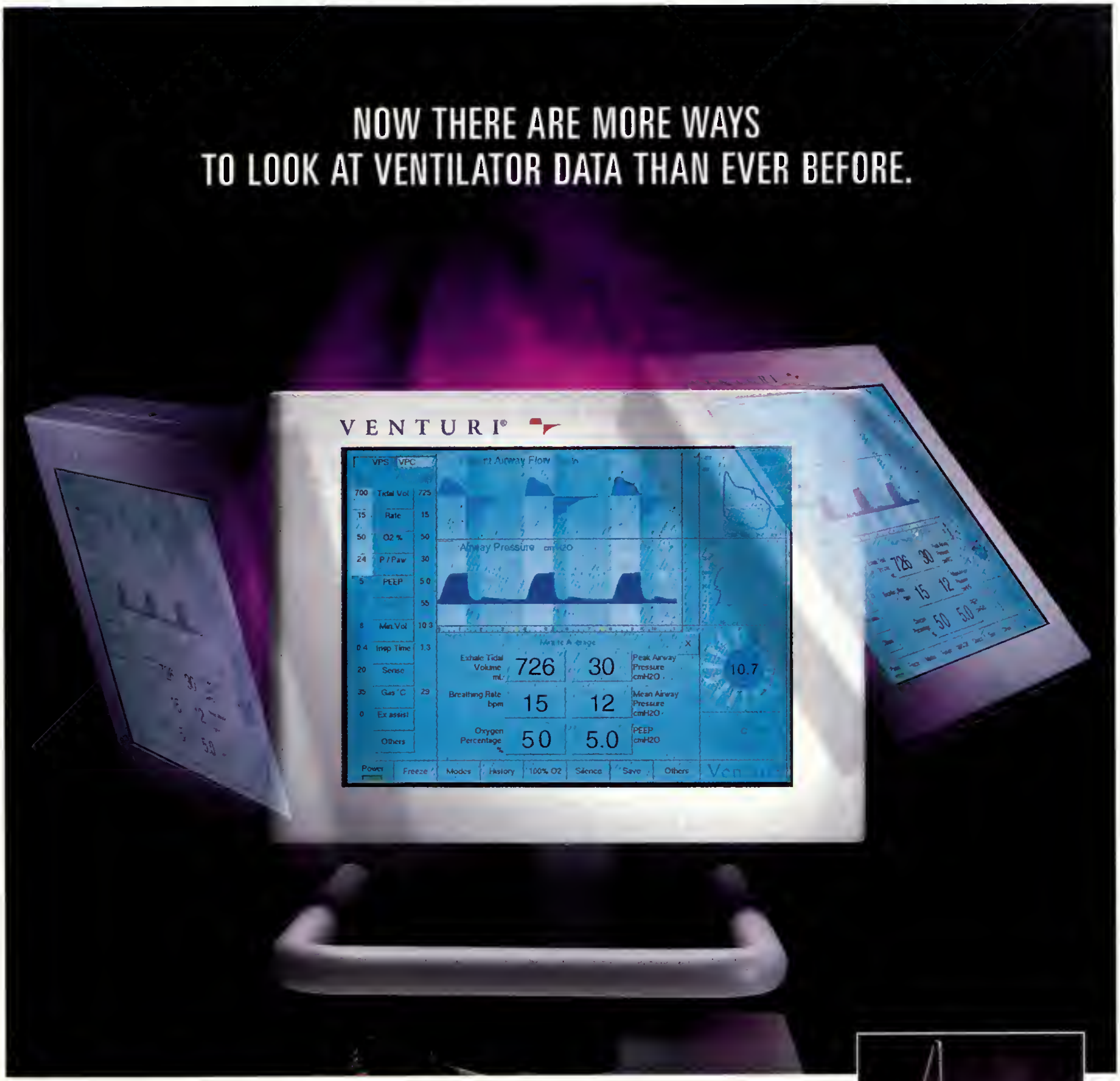
Opportunistic fungal infection is a common cause of serious morbidity and mortality in immunocompromised patients. These infections occur primarily in patients with chemotherapy-induced neutropenia, acquired immunodeficiency syndrome. or immunosuppression after solid organ or bone marrow transplantation. The most important opportunistic fungal pathogens include Cryptococcus neoformans, Candida and Aspergillus species, and the fungi that cause mucormycosis. Opportunistic pneumonia caused by previously unrecognized pathogens, such as Fusarium, Penicillium, and the dematiaceous fungi, are increasingly reported. The clinical and radiologic features of opportunistic fungal pneumonia are highly variable and often nonspecific. Diagnosis requires knowledge of the various modes of presentation, radiologic manifestations, and epidemiology of these infections. Because many of these organisms can colonize the upper airway, sputum cultures are considered diagnostically unreliable. Instead, definitive diagnosis requires culture of the fungus from infected tissue or demonstration of the organism on microscopic examination.

Information in the ICU: Are We Being Honest with Our Patients? The Results of a European Questionnaire—Vincent JL. Intensive Care Med 1998;24(12):1251.

BACKGROUND: We were interested in determining the current practices and views of European intensive care doctors regarding communication with patients and informed consent for interventions. METHODS: A questionnaire was sent to the 1272 western European doctor members of the European Society of Intensive Care Medicine. All questionnaires were anonymous. Five hundred four completed questionnaires from 16 western European countries were analyzed. RESULTS: Of the respondents, 25% said they would always give complete information to a patient, although 35% felt they should. Thirty-two percent would give complete details of an iatrogenic incident, but 70% felt they should. There were significant differences in these attitudes between doctors from different countries, with doctors from the Netherlands more likely to give complete information, and doctors from Greece, Spain and Italy less likely. Fifty percent of the respondents required written consent for surgery, but for insertion of an arterial catheter oral consent was more widely accepted. The Netherlands and Scandinavia generally accepted oral requests for procedures, while Germany and the United Kingdom preferred written requests. Doctors of all countries were generally happy with their current practice concerning informed consent. Seventy-five percent would accept the right of a patient to refuse treatment, but 19% would carry out the procedure against the patient's wishes. CONCLUSIONS: Doctors are often not completely honest with their patients regarding their diagnosis or prognosis, or in the event of an iatrogenic incident. However, most doctors will respect a patient's right to refuse treatment. Informed consent practices vary substantially and are largely determined by locally accepted policy and accepted by doctors working in those areas.

Airway Occlusion Pressure at 0.1 S (P0.1) After Extubation: An Early Indicator of Postextubation Hypercapnic Respiratory Insufficiency—Hilbert G, Gruson D, Portel L, Vargas F, Gbikpi-Benissan G, Cardinaud JP. Intensive Care Med 1998;24(12):1277.

OBJECTIVE: To examine variables associated with postextubation respiratory distress in chronic obstructive pulmonary disease (COPD) patients. DESIGN: Prospective, clinical investigation. SETTING: Intensive care unit of a university hospital. PATIENTS: Forty COPD patients, considered ready for extubation. MEASUREMENTS AND MAIN RESULTS: We recorded, from the digital display of a standard ventilator, breathing frequency (f), tidal volume (V_T) and f/V_T for the respiratory pattern, airway occlusion pressure at 0.1 s (P0.1) for the respiratory drive and measured blood gases: i) before extubation, following 30 min of a 6 cm H_2O pressure support (PS) ventilation trial, ii) 1 h after extubation, at the 30th min of a face mask 4 cm H_2O PS ventilation trial. According to the weaning outcome, the patients were divided into two groups: respiratory distress, and non-respiratory distress within 72 h of the discontinuation of mechanical ventilation. The respiratory distress was defined as the combination of f more than 25 breaths/min, an increase in P_{aCO_2} of at least 20% compared with the value measured after extubation, and pH lower than 7.35. We determined whether those



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patients who developed respiratory distress after extubation differed from those who did not. Respiratory pattern data and arterial blood gases recorded, either before or after extubation, and P0.1 recorded before extubation, were inadequate to differentiate the two groups. Only P0.1 recorded 1 h after the discontinuation of mechanical ventilation differentiated the patients who developed respiratory distress from those who did not (4.2±0.9 vs 1.8±0.8, $p < 0.01$). CONCLUSIONS: P0.1 recorded after extubation may be a good indicator of postextubation respiratory distress. Measuring P0.1 and/or the analysis of the evolution of this parameter could facilitate decisions during the period following extubation.

Evidence of the Effectiveness of Continuous Positive Airway Pressure in the Treatment of Sleep Apnea/Hypopnea Syndrome—Ballester E, Badia JR, Hernandez L, Carrasco E, de Pablo J, Fornas C, et al. Am J Respir Crit Care Med 1999;159(2):495.

Continuous positive airway pressure (CPAP) is worldwide considered as the standard treatment of sleep apnea/hypopnea syndrome (SAHS) although studies on the effectiveness of this treatment are limited. The aim of our study was to evaluate the effectiveness of CPAP in improving SAHS-related symptoms, daytime function, perceived health status, and quality of life in patients with moderate to severe SAHS. The effect of conservative treatment (CT) measures-sleep hygiene and weight loss- was compared with CT + CPAP. We included 105 consecutive patients (13 females, age 53 ± 10 yr, body mass index [BMI] = 32 ± 6 kg/m^2, apnea/hypopnea index [AHI] = 56 ± 20, Epworth sleepiness scale [ESS] = 12 ± 5) who met our criteria for CPAP treatment. Patients were randomly allocated in two groups of similar characteristics. Group 1 (n = 37) was asked to improve sleep hygiene and started a weight loss program. Group 2 (n = 68) received, in addition, treatment with CPAP. Both groups were followed through weekly telephone calls and appointments. Sleepiness, other symptoms related to SAHS, daytime function, perceived health status, and quality of life were assessed through questionnaires at inclusion and after 3 mo of treatment. The relief of sleepiness and other SAHS-related clinical symptoms and improvement in perceived health status was much greater in Group 2 receiving CT + CPAP compared with Group 1, only receiving CT. The odds of experiencing a treatment response with CPAP + CT compared with CT alone was 6.52 (odds ratio [OR] = 2.51 to 17.6, 95% confidence interval [95% CI]). CPAP is currently the treatment of choice. At this time, the indication of CPAP treatment in moderate to severe SAHS is adequately supported.

Elevated Asthma Morbidity in Puerto Rican Children: A Review of Possible Risk and Prognostic Factors—Lara M, Morgenstern H, Duan N, Brook RH. West J Med 1999;170(2):75.

Latino children represent a significant proportion of all US children, and asthma is the most common chronic illness affecting them. Previous research has revealed surprising differences in health among Latino children with asthma of varying countries of family origin. For instance, Puerto Rican children have a higher prevalence of asthma than Mexican American or Cuban American children. In addition, there are important differences in family structure and socioeconomic status among these Latino populations: Cuban Americans have higher levels of education and family income than Mexican-Americans and Puerto Ricans; mainland Puerto Rican children have the highest proportion of households led by a single mother. Our review of past research documents differences in asthma outcomes among Latino children and identifies the possible genetic, environmental, and health care factors associated with these differences. Based on this review, we propose research studies designed to differentiate between mutable and immutable risk and prognostic factors. We also propose that the sociocultural milieus of Latino subgroups of different ethnic and geographic origin are associated with varying patterns of risk factors that in turn lead to different morbidity patterns. Our analysis provides a blueprint for future research, policy development, and the evaluation of multifactorial interventions involving the collaboration of multiple social sectors, such as health care, public health, education, and public and private agencies.

Response to Inhaled Nitric Oxide in Acute Lung Injury Depends on Distribution of Pulmonary Blood Flow Prior to Its Administration—Gust R, McCarthy TJ, Kozlowski J, Stephenson AH, Schuster DP. Am J Respir Crit Care Med 1999;159(2):563.

Responses to inhaled nitric oxide (iNO) in acute lung injury (ALI), as evidenced by improvements in oxygenation, are variable. We hypothesized that the effect of iNO may be related to the pre-iNO distribution of pulmonary blood flow (PBF). In the present study we evaluated the effect of iNO on PBF in normal healthy dogs and in a canine model of ALI induced by oleic acid (OA). In Group "OA only" (n = 5), ALI was induced by central venous injection of 0.08 mL/kg OA. In Group "E+OA" (n = 5), hypoxic pulmonary vasoconstriction after ALI was blocked with low-dose endotoxin (15 microg/kg of Escherichia coli endotoxin) administered 30 min before giving the same dose of OA. Measurements of regional PBF and lung water concentration (LWC) using positron emission tomography (PET) and H215O were performed before and after OA or placebo, and then again at concentrations of 10, 40, and 0 ppm iNO. One hundred twenty minutes after OA injury, P_{aO_2}/F_{IO_2} fell significantly in Group OA only, from 567 ± 32 to 437 ± 67 mm Hg. In these animals, PBF redistributed from the dorsal edematous regions of the lungs to the nondependent zones, thus partially preserving normal ventilation/perfusion relationships. As in the normal animals, in Group OA only, iNO did not significantly change either PBF or oxygenation. In Group E+OA, the administration of low-dose endotoxin eliminated perfusion redistribution from the dorsal edematous lung regions. As a result, P_{aO_2}/F_{IO_2} fell from 558 ± 70 to 119 ± 53 mm Hg, a decrease that was significantly greater than that in Group OA only. In Group E+OA, administration of iNO restored perfusion redistribution to a similar level as in Group OA only, which was associated with a significant improvement in P_{aO_2}/F_{IO_2}, from 119 ± 53 to 251 ± 159 (10 ppm iNO), and 259 ± 165 mm Hg (40 ppm iNO). We conclude that the effect of iNO on oxygenation after ALI depends on the pre-iNO perfusion pattern, which may help explain the variable response to iNO often observed in patients with acute respiratory distress syndrome.

Response to Inhaled Nitric Oxide in Patients with Acute Right Heart Syndrome—Bhorade S, Christenson J, O'connor M, Lavoie A, Pohlman A, Hall JB. Am J Respir Crit Care Med 1999;159(2):571.

Inhaled nitric oxide (iNO), a selective pulmonary vasodilator, has been shown to decrease pulmonary artery pressures but not increase cardiac output in hemodynamically stable patients with a variety of causes of pulmonary hypertension. The response to iNO in hemodynamically unstable patients with acute right heart syndrome has not been previously described. We determined the response to iNO in 26 critically ill adult patients with acute right heart failure defined by echocardiographic criteria. Patients received iNO through the inspiratory limb of the ventilator in increments of 10 ppm with hemodynamic and gas-exchange measurements made before and after each level. When maximal effect was seen, iNO was discontinued to compare parameters with baseline. iNO significantly increased cardiac output (5.5 ± 3 to 6.4 ± 4 L/min), stroke volume (54 ± 27 to 65 ± 38 mL), and mixed-venous oxygen saturation (69 ± 8 to 73 ± 10%), all $p < 0.01$. With discontinuation of iNO, all parameters returned immediately to baseline. These parameters of improved perfusion were related to a decrease in pulmonary vascular pressures and resistance. In a subset of approximately 50% of patients, these changes were substantial (> 20%) and in approximately 25% of all patients, the improvement in hemodynamic measures permitted a decrease in other vasoactive drug administration.

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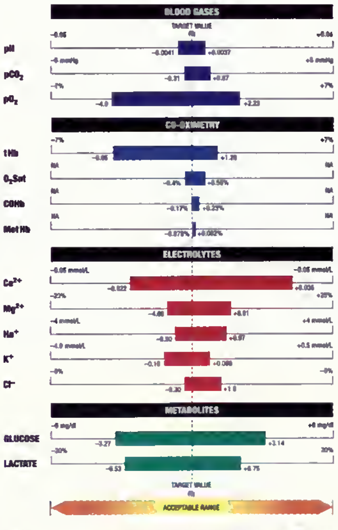

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The mean concentration of iNO required to achieve these effects was 35 ppm, and 85% of patients exhibiting a substantial improvement in hemodynamics did so at a concentration of iNO of less than or equal to 40 ppm. Underlying causes of right heart failure and baseline hemodynamics did not predict response to iNO, but the use of alpha-agonist catecholamines did. We conclude iNO improves hemodynamics in patients with respiratory failure, shock, and right ventricular dysfunction. Although mortality was not a key end point in this pilot study, it was high for both responders and nonresponders to this therapy. Further evaluation of the role of iNO in this patient population is supported by these data.

Ventilator-Associated Lung Injury Decreases Lung Ability to Clear Edema in Rats—Lecuona E, Saldias F, Comellas A, Ridge K, Guerrero C, Sznajder JI. Am J Respir Crit Care Med 1999;159(2):603.

Ventilator-associated lung injury (VALI) is caused by high tidal volume (V_T) excursions producing microvascular leakage and pulmonary edema. However, the effects of VALI on lung edema clearance and alveolar epithelial cells' Na,K-ATPase function have not been elucidated. We studied lung edema clearance in the isolated-perfused rat lung model after ventilation for 25, 40, and 60 min with high V_T (peak airway opening pressure [Pao] of approximately 35 cm H_2O) and compared them with low V_T ventilation (Pao approximately 8 cm H_2O), moderate V_T ventilation (Pao approximately 20 cm H_2O), and nonventilated rats. Lung edema clearance in control rats was 0.50 ± 0.02 mL/h and decreased after 40 and 60 min of high V_T to 0.26 ± 0.03 and 0.11 ± 0.08 mL/h, respectively ($p < 0.01$), but did not change after low V_T and moderate V_T ventilation at any time point. Lung permeability to small (22Na+, [3H] mannitol) and large solutes (fluorescein isothiocyanate-tagged albumin [FITC-albumin]) increased significantly in rats ventilated for 60 min with high V_T, compared with low V_T, moderate V_T, and control rats ($p < 0.01$). Paralleling the impairment in lung edema clearance we found a decrease in Na,K-ATPase activity in alveolar type II (ATII) cells isolated from rats ventilated with moderate V_T and high V_T for 40 min without changes in alpha1 Na,K-ATPase mRNA. We reason that VALI decreases lung ability to clear edema by inhibiting active sodium transport and Na,K-ATPase function in the alveolar epithelium.

Assessment of Airway Function Using Partial Expiratory Flow-Volume Curves: How Reliable Are Measurements of Maximal Expiratory Flow at FRC During Early Infancy?—Henschen M, Stocks J. Am J Respir Crit Care Med 1999;159(2):480.

We investigated the extent to which measurements of maximal expiratory flow at FRC (V EmaxFRC) are influenced by the dynamic increase of FRC in young infants by superimposing partial forced expiratory flow-volume curves on those obtained after lung inflation to 2 kPa (20 cm H_2O) in 12 infants during the first month of life. The elastic equilibrium volume (EEV) of the respiratory system was estimated by extrapolating the passive expiratory time constant (obtained after lung inflation but prior to forced deflation) to zero flow. There was a very strong relationship between V EmaxFRC (which ranged from 11 to 190 mL/s) and the extent to which FRC was dynamically increased above EEV (range: 0 to 5 mL/kg), $r^2 = 0.88$. The results of this study suggest that, although V EmaxFRC remains a useful means of measuring peripheral airway function in infants, its values should be interpreted with caution during the neonatal period. In particular, the relatively high V EmaxFRC values reported in healthy newborn infants may reflect differences in breathing strategy rather than airway structure. More meaningful within- and between-infant comparisons of peripheral airway function may be obtained by calculating forced expiratory flows at a fixed interval (e.g., 3 mL/kg) above EEV, rather than at the FRC that is operational at the time of measurement.

Airway Obstruction and Perioperative Complications in Smokers Undergoing Abdominal Surgery—Warner DO, Warner MA, Offord KP, Schroeder DR, Maxson P, Scanlon PD. Anesthesiology 1999;90(2):372.

BACKGROUND: The goal of this study was to determine whether airway obstruction determined by preoperative spirometry predicts perioperative complications in smokers undergoing abdominal surgery whose treatment is managed according to current clinical practice. METHODS: A pulmonary function database identified patients undergoing abdominal surgery who met the following criteria for airway obstruction (n = 135): a forced expiratory volume less than 40% of predicted normal value, a forced expiratory volume:forced vital capacity ratio less than the lower limit of predicted normal, a smoking history of more than 20 pack-years, and an age older than 35 yr. A group of patients without airway obstruction (n = 135) was matched for gender, surgical site (upper vs. lower abdominal), smoking history, and age. Medical records were reviewed by an abstractor to identify perioperative complications that occurred within 30 days after surgery. RESULTS: The forced expiratory volume values were 0.9±0.21 (mean ± SD) and 2.9±0.61 in patients with and without airway obstruction, respectively. When analyzed by conditional logistic regression using the 1:1 matched-pairs feature, including age, pack-year smoking history, site of incision, and current smoking status as covariates, in patients with airway obstruction bronchospasm was more likely to develop (odds ratio, 6.9 [95% confidence interval, 1.2 to 38.4]) but the patients were not more likely to need prolonged endotracheal intubation (odds ratio, 1.1 [95% confidence interval, 0.4 to 3.2]). They were also no more likely to need prolonged intensive care admission or readmission. The frequency of other complications was less than 5%. CONCLUSION: When other factors were considered, preoperative airway obstruction predicted the occurrence of bronchospasm, but not prolonged endotracheal intubation, in smokers undergoing abdominal surgery who are treated according to current clinical practices. *See the related editorial: **The Role of Spirometry in Predicting Pulmonary Complications after Abdominal Surgery: Progressing Toward an Answer**—Kimball WR. Anesthesiology 1999;90(2):356–357.*

Higher Dosage Nicotine Patches Increase One-Year Smoking Cessation Rates: Results from the European CEASE Trial. Collaborative European Anti-Smoking Evaluation. European Respiratory Society—Tonnesen P, Paoletti P, Gustavsson G, Russell MA, Saracci R, Gulsvik A, et al. Eur Respir J 1999;13(2):238.

The Collaborative European Anti-Smoking Evaluation (CEASE) was a European multicentre, randomized, double-blind placebo controlled smoking cessation study. The objectives were to determine whether higher dosage and longer duration of nicotine patch therapy would increase the success rate. Thirty-six chest clinics enrolled a total of 3.575 smokers. Subjects were allocated to one of five treatment arms: placebo and either standard or higher dose nicotine patches (15 mg and 25 mg daily) each given for 8 or 22 weeks with adjunctive moderately intensive support. The 12 month sustained success rates were: 25 mg patch for 22 weeks (L-25), 15.4%; 25 mg patch for 8 weeks (S-25), 15.9%; 15 mg patch for 22 weeks (L-15), 13.7%; 15 mg patch for 8 weeks (S-15), 11.7%; and placebo (P-0) 9.9% (placebo versus 15 mg, $p<0.05$: 25 mg versus 15 mg, $p<0.03$; 25 mg versus placebo, $p<0.001$, Chi-squared test). There was no significant difference in success rate between the two active treatment durations. Of the first week abstainers (n=1.698), 25.1% achieved success at 12 months as opposed to first week smokers, 2.7% of 1.877 subjects ($p< 0.001$). In summary, a higher than standard dose of nicotine patch was associated with an increase in the long-term success in smoking cessation but continuation of treatment beyond 8–12 weeks did not increase the success rates.

Dose-Response Slope of Forced Oscillation and Forced Expiratory Parameters in Bronchial Challenge Testing—Bohadana AB, Peslin R, Megherbi SE, Teculescu D, Sauleau EA,

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Wild P, Pham QT. Eur Respir J 1999;13(2): 295.

In population studies, the provocative dose (PD) of bronchoconstrictor causing a significant decrement in lung function cannot be calculated for most subjects. Dose-response curves for carbachol were examined to determine whether this relationship can be summarized by means of a continuous index likely to be calculable for all subjects, namely the two-point dose response slope (DRS) of mean resistance (Rm) and resistance at 10 Hz (R10) measured by the forced oscillation technique (FOT). Five doses of carbachol (320 microg each) were inhaled by 71 patients referred for investigation of asthma (n=16), chronic cough (n=15), nasal polyposis (n=8), chronic rhinitis (n=8), dyspnoea (n=8), urticaria (n=5), post-anaphylactic shock (n=4) and miscellaneous conditions (n=7). FOT resistance and forced expiratory volume in one second (FEV_1) were measured in close succession. The PD of carbachol leading to a fall in $FEV_1 \geq 20\%$ (PD20) or a rise in Rm or R10 ≥ 47% (PD47,Rm and PD47,R10) were calculated by interpolation. DRS for FEV_1 ($DRSFEV_1$), Rm (DRSRm) and R10 (DRSR10) were obtained as the percentage change at last dose divided by the total dose of carbachol. The sensitivity (Se) and specificity (Sp) of DRSRm, DRS10 Δ%Rm and Δ%R10 in detecting spirometric bronchial hyperresponsiveness (BHR, fall in $FEV_1 \geq 20\%$) were assessed by receiver operating characteristic (ROC) curves. There were 23 (32%) "spirometric" reactors. PD20 correlated strongly with $DRSFEV_1$ (r0.962; p=0.0001); PD47,Rm correlated significantly with DRSRm (r0.648; p=0.0001) and PD47,R10 with DRSR10 (r0.552; p=0.0001). $DRSFEV_1$ correlated significantly with both DRSRm (r=0.700; p=0.0001) and DRSR10 (r=0.784; p=0.0001). The Se and Sp of the various FOT indices to correctly detect spirometric BHR were as follows: DRSRm: Se=91.3%, Sp=81.2%; DRSR10: Se=91.3%, Sp=95.8%; Δ%Rm: Se=86.9%, Sp=52.1%; and Δ%R10: Se=91.3%, Sp=58.3%. Dose-response slopes of indices of forced oscillation technique resistance, especially the dose-response slope of resistance at 10Hz are proposed as simple quantitative indices of bronchial responsiveness which can be calculated for all subjects and that may be useful in occupational epidemiology.

Risk Factors for Lower Airway Bacterial Colonization in Chronic Bronchitis—Monso E, Rosell A, Bonet G, Manterola J, Cardona PJ, Ruiz J, Morera J. Eur Respir J 1999;13(2):338.

The aim of this study was to determine the prevalence and risk factors for lower airway bacterial colonization (LABC) in stable chronic bronchitis (CB). Forty-one outpatients with CB were enrolled in the study (age 63.8±9.1 yrs (mean±SD); forced expiratory volume in one second (FEV_1)/forced vital capacity (FVC) 62.8±11.2; current/former smokers 24/17). All patients had normal chest radiographs and an indication for performing fibreoptic bronchoscopy (pulmonary nodule, remote haemoptysis). The protected specimen brush (PSB) was used for bacterial sampling, and concentrations ≥ 1,000 colony-forming units (cfu) x mL^{-1} were considered positive for LABC. The repeatability of the procedure in CB was assessed in a random subsample of 18 subjects. A 72.2% quantitative agreement was found in the repeatability assessment of the PSB technique. Positive PSB cultures, obtained in 9 out of 41 (22%) patients, mainly yielded Haemophilus influenzae. The logistic regression model, used to determine which variables were related to colonization, showed that LABC was associated with current smoking (odds ratio (OR) 9.83, confidence interval (CI) 1.16–83.20) and low FVC (OR 0.73, CI 0.65–0.81). Age and FEV_1 were not related to LABC. It was concluded that the prevalence of LABC in stable CB is high (22%), and current smoking is an important risk factor.

Risk Factors for Community-Acquired Pneumonia in Adults: A Population-Based Case-Control Study—Almirall J, Bolibar I, Balanzo X, Gonzalez CA. Eur Respir J 1999;13(2):349.

Although community-acquired pneumonia (CAP) remains a major cause of hospitalization and death, few studies on risk factors have been performed. A population-based case-control study of risk factors for CAP was carried out in a mixed residential-industrial urban area of 74,610 adult inhabitants in the Maresme (Barcelona, Spain) between 1993 and 1995. All patients living in the area and clinically suspected of having CAP at primary care facilities and hospitals were registered. In total, 205 patients with symptoms, signs and radiographic infiltrate compatible with acute CAP participated in the study. They were matched by municipality, sex and age with 475 controls randomly selected from the municipal census. Risk factors relating the subject's characteristics and habits, housing conditions, medical history and treatments were investigated by means of a questionnaire. In the univariate analysis, an increased risk of CAP was associated with low body mass index, smoking, respiratory infection, previous pneumonia, chronic lung disease, lung tuberculosis, asthma, treated diabetes, chronic liver disease, and treatments with aminophiline, aerosols and plastic pear-spacers. In multivariate models, the only statistically significant risk factors were current smoking of >20 cigarettes x day^{-1} (odds ratio (OR)=2.77; 95% confidence interval (CI) 1.14–6.70 compared with never-smokers), previous respiratory infection (OR=2.73; 95% CI 1.75–4.26), and chronic bronchitis (OR=2.22; 95% CI 1.13–4.37). Benzodiazepines were found to be protective in univariate and multivariate analysis (OR=0.46; 95% CI 0.23–0.94). This population-based study provides new and better established evidence on the factors associated with the occurrence of pneumonia in the adult community.

Differences in Spontaneous Breathing Pattern and Mechanics in Patients with Severe COPD Recovering from Acute Excerbation—Vitacca M, Porta R, Bianchi L, Clini E, Ambrosino N. Eur Respir J 1999;13(2):365.

The aims of this study were to assess spontaneous breathing patterns in patients with chronic obstructive pulmonary disease (COPD) recovering from acute exacerbation and to assess the relationship between different breathing patterns and clinical and functional parameters of respiratory impairment. Thirty-four COPD patients underwent assessment of lung function tests, arterial blood gases, haemodynamics, breathing pattern (respiratory frequency (fR), tidal volume (V_T), inspiratory and expiratory time (tI and tE), duty cycle (tI/ttot), V_T/tI) and mechanics (oesophageal pressure (Poes), work of breathing (WOB), pressure-time product and index, and dynamic intrinsic positive end-expiratory pressure (PEEPi,dyn)). According to the presence (group 1) or absence (group 2) of Poes swings during the expiratory phase (premature inspiration), 20 (59%) patients were included in group 1 and 14 (41%) in group 2. Premature inspirations were observed 4.5±6.4 times x min^{-1} (range 1–31), i.e. 20±21% (3.7–100%) of total fR calculated from V_T tracings. In group 1 the coefficient of variation in V_T, tE, tI/ttot, PEEPi,dyn, Poes and WOB of the eight consecutive breaths immediately preceding the premature inspiration was greater than that of eight consecutive breaths in group 2. There were no significant differences in the assessed parameters between the two groups in the overall population, whereas patients with chronic hypoxaemia in group 1 showed a more severe impairment in clinical conditions, mechanics and lung function than hypoxaemic patients in group 2. In spontaneously breathing patients with chronic obstructive pulmonary disease recovering from an acute exacerbation, detectable activity of inspiratory muscles during expiration was found in more than half of the cases. This phenomenon was not associated with any significant differences in anthropometric, demographic, physiological or clinical characteristics.

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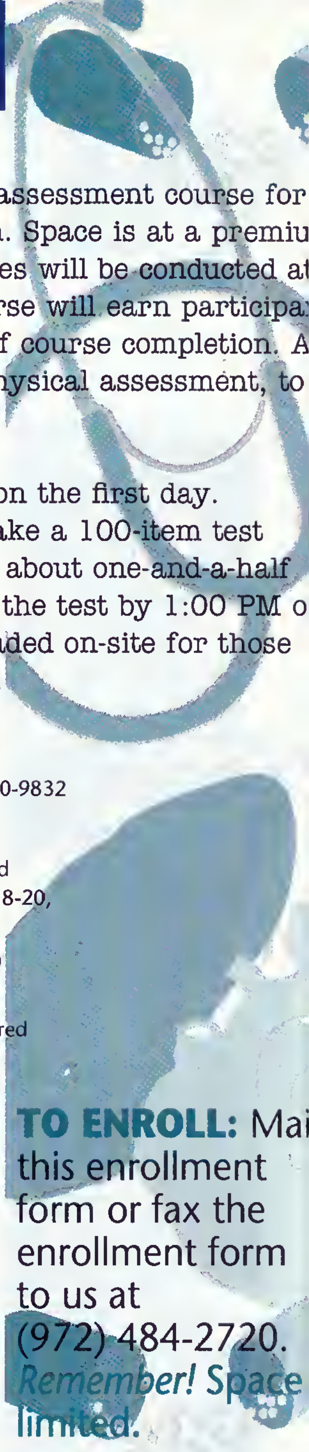

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Therapist-Directed Protocols: Their Time Has Come

Marin H Kollef MD

Protocols or practice guidelines are an increasingly popular means of standardizing medical practices. Protocols are used to guide several aspects of respiratory care for hospitalized patients, including the weaning of mechanical ventilation,[1,2] infection-control practices for the prevention of ventilator-associated pneumonia,[3,4] chest physiotherapy,[5] the clinical use of arterial blood gases,[6] and inhaled bronchodilator administration.[7,8] Many of these protocols were specifically designed for implementation by respiratory therapists in order to reduce medical care costs, unburden physicians from tasks that can be performed by respiratory therapists,[9] and to improve patient outcomes. Other potential benefits include enabling the identification of potential improvements in clinical practices, improving the quality of nonblinded clinical research, and establishing a foundation for the performance of quality improvement efforts.[10,11] Standardized protocols help to minimize errors in clinical management, to improve the effectiveness of available treatments, and to increase the accountability of medical providers. They also provide a reference by which to assess practices that deviate from the accepted standard.[12]

Several clinical studies have clearly demonstrated the ability of respiratory therapists to prescribe and carry out standardized respiratory treatments for hospitalized non-ICU patients. Stoller et al conducted a randomized controlled trial comparing respiratory therapist-directed respiratory care to physician-directed respiratory care,[13] and found that respiratory therapist-directed respiratory care demonstrated better agreement with the standard care plan of their institution and was associated with lower costs than physician-directed respiratory care—without any increase in adverse events, hospital mortality, or length of hospital stay. Similar studies have focused on specific aspects of respiratory care, such as weaning from mechanical ventilation, and these studies also found that respiratory therapist-directed care is less expensive and without detriment to the quality of care.[1,2,14] Alexander et al found that simple respiratory care guidelines, based on clinical practices supported by peer-reviewed investigations, reduced unnecessary respiratory treatments without compromising patient care.[5] These reductions were associated with significant savings and allowed respiratory therapists to concentrate their efforts on the treatments that were most likely to benefit patient outcomes. However, it is important to note that most of the institutions involved in the study of protocols and guidelines for respiratory care (eg, The Cleveland Clinic Foundation and Cedars-Sinai Medical Center) have extensive experience with protocol development and utilization. Therefore, the results of clinical investigations examining protocol-directed therapy from these institutions may, in part, be a result of their medical practice cultures (ie, those that use protocol-directed treatments). The importance of such an environment for the successful implementation of quality improvement efforts, including protocol-based therapies, was recently described by Clemmer et al.[15]

As the five articles in this issue of RESPIRATORY CARE suggest, therapist-directed protocols are an effective strategy for standardizing medical practices and focusing the efforts of health care workers on specific tasks that must be carried out accurately and timely. As well, protocols can serve as important educational tools, providing clinicians information on the appropriateness of various medical practices for specific disease processes.[13] However, the effective implementation of protocol-directed therapies requires a dedicated effort by the institution. Protocols must be updated regularly to optimize their clinical applicability, there must be adequate support staff to carry out the protocols fully and efficiently, and the protocols must not interfere with the clinician's ability to alter practices based on clinical experience.[15,16] A recent investigation by Ely et al[17] suggests that staff compliance with protocols may be an important barrier to successful implementation. Thus, a successful protocol system must be designed with a working knowledge of existing clinical practices and plans for regular review so as to maximize compliance.

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Trial of a Therapist-Directed Protocol for Weaning Bronchodilator Therapy in Children with Status Asthmaticus

Michelle B Lierl MD, Scott Pettinichi RRT, Katharine D Sebastian, and Uma Kotagal MBBS MSc

BACKGROUND: The Children's Hospital Medical Center in Cincinnati, Ohio implemented a respiratory therapist-directed protocol for weaning β-agonist aerosols in pediatric status asthmaticus. We studied whether the protocol conferred advantages over the existing practice, wherein changes to the frequency of aerosol administration were directed by the physician. METHODS: Clinical outcomes were compared between 71 controls (C) and 70 protocol patients (P). RESULTS: In the P group, fewer aerosols were administered, and the time required to wean aerosol frequency to every 6 hours was shorter. However, the lag time between reaching the 6-hour aerosol frequency and the discharge order was longer in the protocol group. There was no significant difference in length of stay, cases where aerosol frequency was re-increased, returns to the emergency department, or hospital readmission within 1 week. Respiratory therapist compliance to the protocol improved during the study period, but review of the therapist records suggests that approximately one third of the aerosol treatments administered during the protocol could have been withheld, given the specified objective criteria of respiratory distress. CONCLUSION: With carefully designed assessment criteria and protocol training, a respiratory therapist-directed protocol for weaning β-agonist aerosols can improve pediatric asthma patient care in a teaching hospital. [Respir Care 1999;44(5):497–505] *Key words: asthma, status asthmaticus, pediatrics, bronchodilator, respiratory therapy, clinical outcomes, albuterol, therapist-directed protocol.*

Introduction

Asthma is one of the leading causes of admissions to children's hospitals in the United States. The treatment of status asthmaticus includes administration of supplemental oxygen as needed, systemic corticosteroids, and aerosolized β-agonists.[1] The administration of frequent or continuous doses of short-acting β-agonists by inhalation is considered the most effective measure for reversal of acute airway obstruction.[2–4] As part of a program to improve the clinical effectiveness of care for children admitted for treatment of status asthmaticus, a protocol for the administration of β-agonist aerosols was developed with the goal of reducing unnecessary therapy.

The Children's Hospital Medical Center in Cincinnati, Ohio, has a large pediatric residency program at which the traditional approach to delivery of β-agonist aerosols had been as follows: Aerosols were given by the respiratory therapist (RT), following physician orders that prescribed initial frequency. The decision to change frequency of aerosol administration was initiated by the physician following reexaminations. Because of the other responsibilities of the resident physicians, this approach caused delays in decreasing aerosol frequency, which increased length of hospital stay for some patients. In most cases the patient would be discharged when β-agonist aerosols were needed no more often than every 6 hours.

The goals of this project were:

1. to develop standardized criteria for changing the frequency of β-agonist aerosols,
2. to improve the responsiveness of the system to the clinical status of the patient by allowing more frequent changes in the aerosol administration interval, based on clinical status,

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3. to determine whether application of this protocol resulted in decreased length of hospital stay for children with status asthmaticus.

Methods

Development of the β-Agonist Weaning Protocol

The protocol was developed by a multidisciplinary team consisting of an RT, a physician specializing in pediatric allergy and pulmonary medicine, a pediatric chief resident, and a registered nurse. Criteria were formulated for respiratory distress, including vital signs, physical examination, and peak flow (for children old enough to perform this test). To test the reliability of the criteria, each member of the team independently assessed the same pediatric asthma inpatients and rated the patients using the proposed criteria. The criteria were then revised to reduce ambiguities and areas of inconsistency, after which the testing was repeated. When consistent results were obtained by all team members, the criteria were finalized. The criteria of respiratory distress were:

1. Respiratory rate $>$ 2 standard deviations for age.[5]
2. Peak flow $<$ 60% predicted for height (or 60% personal best if known). Peak flow rates were measured in children over the age of 5 years, when acute respiratory distress had subsided, and the patient was clinically stable in the judgement of the RT.[6]
3. Dyspnea (score of 1 or greater).
4. Accessory muscle use (score of 1 or greater).
5. Decreased air exchange (score of 2 or greater).
6. Wheezing (score of 2 or greater).
7. Prolonged expiration (I:E score of 2 or greater).

The scores for each parameter were noted on the RT documentation form (asthma care flow chart, shown in Appendix 1).

The protocol for changing β-agonist aerosol frequency is shown in diagram form in Figure 1, and detailed in Appendix 2. Briefly, the RT assessed the patient prior to each scheduled aerosol treatment, and if any of the criteria of respiratory distress were present, the aerosol was administered. If no criteria of respiratory distress were noted, the aerosol was deferred and the patient was reassessed at the next time interval.

Each patient had oxygen saturation measured by pulse oximetry, and supplemental oxygen was administered as needed to keep oxygen saturation above 91%. However, the requirement for supplemental oxygen was not included as a criterion for the β-agonist administration protocol (in order to avoid excessive administration of β-agonist to patients with coexisting pneumonia or atelectasis).

Peak flow rates were included as part of the RT assessment in children old enough to perform the maneuver correctly (usually over age 5), and only in patients who did not clinically appear to have significant respiratory distress, since the peak flow maneuver can exacerbate bronchospasm in patients with significant airway hyperreactivity. In most cases peak flow measurements were begun after several hours of in-hospital treatment.

Implementation of the Protocol

Educational presentations of the protocol were given to all RTs, nurses, and pediatric residents assigned to the unit where the protocol was to be implemented, and letters were sent to all attending physicians explaining the protocol and inviting them to contact the investigators if they did not want their patients to be managed on the protocol. None of the attending physicians objected to the trial.

The protocol was implemented on a single hospital unit to which patients with status asthmaticus of moderate severity are admitted. A relatively small and stable group of RTs (about 10, including all shifts) was assigned to this unit. Using the asthma care flow sheet, baseline data were collected on 71 patients admitted to the unit during the months of February through May, prior to the introduction of the protocol (the control group). Data were collected on 70 consecutive patients admitted to the same unit during the months of June through mid-September, during implementation of protocol (the protocol group).

This project was reviewed by the institutional review board; informed consent was not deemed necessary since no experimental procedures or medications were involved. The patients' names were not included in the database.

Patient Groups

Patients in both the control and protocol groups were children admitted for treatment of status asthmaticus. None of the patients had a diagnosis of pneumonia, cystic fibrosis, or other chronic underlying pulmonary or cardiac condition, with the exception of bronchopulmonary dysplasia. Patients were excluded from both the control group and the protocol group if they were initially admitted to the intensive care unit. Each patient's degree of respiratory distress at the time of admission was quantified as the clinical asthma score. This score was the sum of the points assigned by the RT at the time of the first clinical assessment after admission to the hospital inpatient unit. In most cases, the patient had received several β-agonist aerosols and a dose of systemic corticosteroid medication in the emergency room or in a primary care outpatient setting, prior to this assessment. One point was added to the score for elevated respiratory rate, and one point for supplemental oxygen requirement. The score did not include peak flow rates, since many of the children were too young or initially in too much respiratory distress to perform this maneuver.

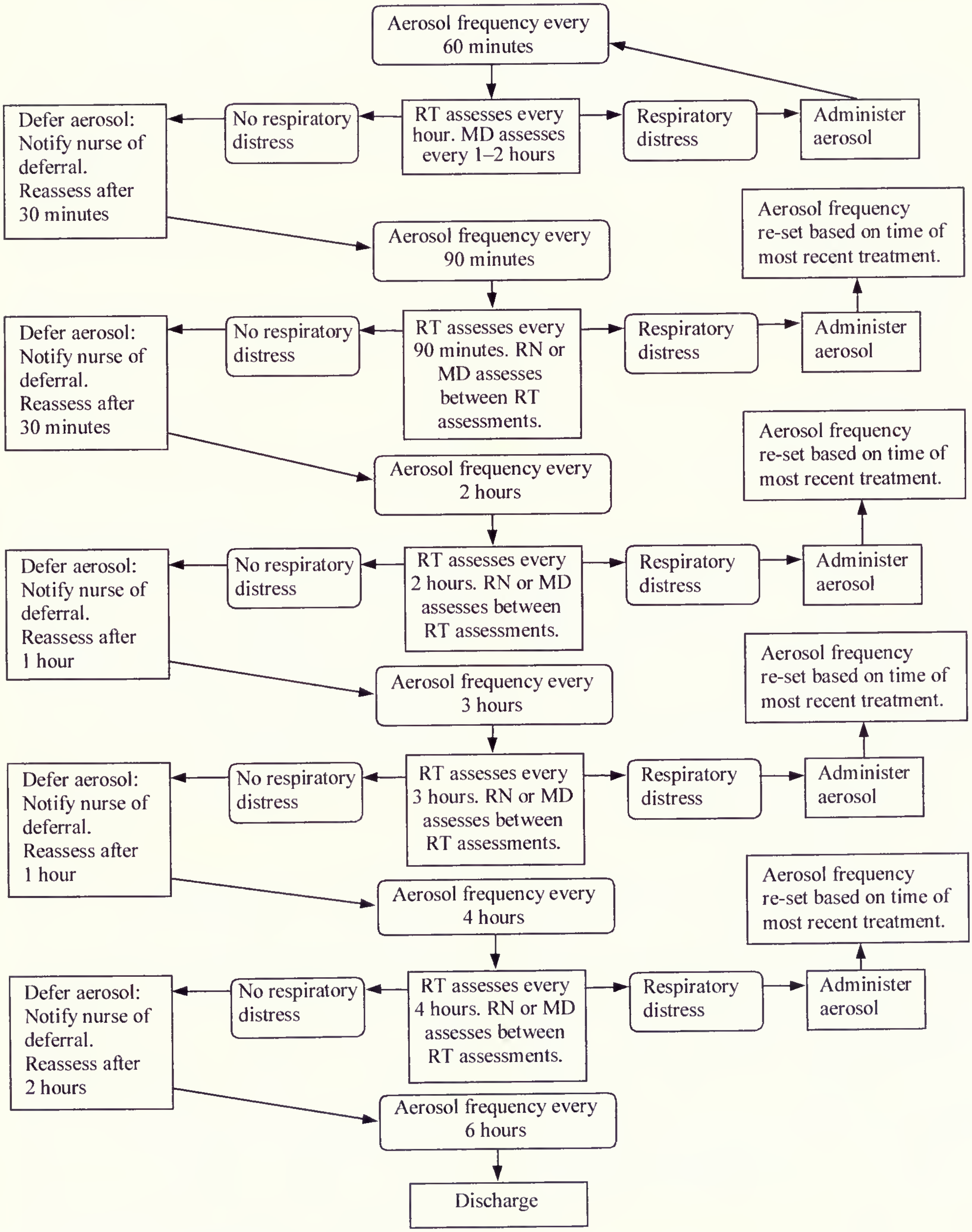
Aerosol frequency every 60 minutes
Defer aerosol: Notify nurse of deferral. Reassess after 30 minutes
No respiratory distress
RT assesses every hour. MD assesses every 1–2 hours
Respiratory distress
Administer aerosol
Aerosol frequency re-set based on time of most recent treatment.
Aerosol frequency every 90 minutes
Defer aerosol: Notify nurse of deferral. Reassess after 30 minutes
No respiratory distress
RT assesses every 90 minutes. RN or MD assesses between RT assessments.
Respiratory distress
Administer aerosol
Aerosol frequency re-set based on time of most recent treatment.
Aerosol frequency every 2 hours
Defer aerosol: Notify nurse of deferral. Reassess after 1 hour
No respiratory distress
RT assesses every 2 hours. RN or MD assesses between RT assessments.
Respiratory distress
Administer aerosol
Aerosol frequency re-set based on time of most recent treatment.
Aerosol frequency every 3 hours
Defer aerosol: Notify nurse of deferral. Reassess after 1 hour
No respiratory distress
RT assesses every 3 hours. RN or MD assesses between RT assessments.
Respiratory distress
Administer aerosol
Aerosol frequency re-set based on time of most recent treatment.
Aerosol frequency every 4 hours
Defer aerosol: Notify nurse of deferral. Reassess after 2 hours
No respiratory distress
RT assesses every 4 hours. RN or MD assesses between RT assessments.
Respiratory distress
Administer aerosol
Aerosol frequency every 6 hours
Discharge

Fig. 1. Flow Chart for β-Agonist Weaning Protocol

Table 1. Patient Characteristics

Variable	Protocol Group (n = 73)	Control Group (n = 72)	p Value
Age (Years)			
Mean	4.3 (range 0–16, SD 3.82)	4.7 (range 0–15, SD 3.81)	0.46*
Median	3.0	4.0	
% Male	70.8	64.4	0.41†
Race (Percent)			
African American	53.4	38.9	0.064†
White	43.8	59.7	
Other	2.8	1.4	
Insurance Status (Percent)			
Commercial	54.8	56.9	0.47†
Medicaid	42.5	38.9	
Other	2.7	4.2	
Clinical Asthma Score‡	3.3 (0–10, SD 1.9)	3.4 (1–9, SD 1.8)	0.75*

*Student t test, two-tailed.

†Chi-square test.

‡The clinical asthma score is the sum of scores for each parameter on the asthma care flow sheet, plus one point for elevated respiratory rate for age and one point for requirement for supplemental oxygen.

Data Collection

Data were obtained by hospital chart review. The asthma care flow sheets were reviewed for patients' clinical status and times of aerosol administration. The time required to decrease aerosol frequency to every 6 hours, without a subsequent increase in frequency, was obtained from review of the asthma care flow sheets. Some patients were discharged while still receiving aerosol treatments every 4 hours; this occurred in 28 subjects of the control group and 7 subjects of the protocol group. For these patients, the time at which the discharge order was written was used in place of the time to the 6-hour aerosol frequency, as an indication of discharge readiness. This information was obtained from the physician's order forms. A trained research assistant reviewed each RT assessment to determine whether the protocol had been applied correctly (ie, whether the decision to administer or defer the β-agonist aerosol was justified by the documented clinical assessment). The unit clerk's log was used to determine the date and time of admission to the unit. Transfers to the intensive care unit were determined by review of the physicians' orders. The hospital computer database was searched to determine whether there were any emergency room visits or hospitalizations for asthma within 1 week of discharge. It was assumed that children requiring further emergency treatment would return to this hospital, which serves as the city's primary facility for pediatric hospital care.

Statistical Analysis

A power calculation based on length of stay (mean and standard deviation) for asthma admissions at this institution during the year preceding the study determined that 70 subjects in each group would be sufficient to detect a 25% difference in length of stay at a power of 80% and p value of 0.05.

Data were compared between study and control patients using SAS.[7] Chi-square test was used to compare proportions and a Student t test was done to compare differences in continuous data that were normally distributed. Regression analysis was used to look for relationships between clinical variables and outcomes.

Results

Patient Characteristics

There were no significant demographic differences between the control group and protocol group with regard to age, ethnic distribution, or insurance status (Table 1). Initial clinical severity as assessed by the clinical asthma score was similar for the two groups.

Clinical Outcomes

Table 2 shows that there was a significant decrease in the mean number of aerosols given per patient in the protocol group compared with the control group. The time required to decrease the aerosol frequency to every 6 hours was also significantly lower in the protocol group. However, the protocol group had a significantly longer lag time between reaching a stable aerosol frequency of every 6 hours and the writing of the discharge order. Twenty-five percent of the control group and 39% of the protocol group stayed in the hospital for more than 3 hours after their first

Table 2. Clinical Outcomes of Protocol Trial

Parameter	Control	Protocol
Number of aerosols	14.4 (range 4–42, SD 8.1)	11.1 (range 2–26, SD 5.4)*
Time to q 6-hour aerosols (hours)†	39.5 (range 13–111, SD 20.5)	29.9 (range 7–85, SD 18.9)‡
Mean time: q 6-hour to discharge (hours)§	3.0 (range 0 to 22, SD 5.8)	9.4 (range, 0 to 38, SD 9.3)‖
Length of stay (hours)	42.5 (range 13–111, SD 21.8)	39.3 (range 1–113, SD 20.3)
Increase in frequency¶	1.24 (range 0–9, SD 1.9)	0.82 (range 0–5, SD 1.1)
Transfers to intensive care unit	0	0
Return to emergency department within 1 week	2	1
Return to hospital within 1 week	2	0

Number of aerosols = total number of aerosols per patient given during the hospitalization. q = frequency of aerosol administration.

*$p < 0.005$ (two-tailed Student's t test).

†Time from admission until the first aerosol was given at a 6-hour interval, without a subsequent increase in aerosol frequency. Some patients were discharged on q 4-hour aerosols; for these, the time from admission to the discharge order was used.

‡$p < 0.01$ (two-tailed Student's t test).

§Patients who were discharged prior to weaning to q 6-hour aerosols were counted as zero.

‖$p < 0.0001$ (two-tailed Student's t test).

¶Number of times per patient that aerosol frequency had to be increased, after being decreased.

aerosol interval of 6 hours. Thus, the actual length of hospital stay was not significantly lower in the protocol group. Reasons for the delays in discharge were not determined; there was no significant relationship to the patients' ages, initial clinical severity, dates of admission, or numbers of reversals in the weaning of aerosol frequency.

There was no significant difference between groups in the mean number of times aerosol frequency had to be increased following a decrease, although there was a trend toward fewer setbacks in the protocol group. There was no change in the incidence of adverse events associated with the use of the protocol, as measured by the need for intensive care unit transfers or readmissions following discharge.

Process Outcomes

The protocol was considered to have been followed correctly if aerosols were administered each time criteria for respiratory distress were documented and aerosols were deferred each time the RT documentation showed no signs of respiratory distress. There were a total of 763 decision points in the course of protocol implementation. The protocol was followed correctly throughout the entire hospital stay in only 7 (10%) of the patients. However, in 499 (65%) of all the RT assessments the correct decision to administer or defer the aerosol was made. Nearly all the errors in protocol application were instances of aerosols administered inappropriately, meaning that the RT documented none of the specified criteria of respiratory distress but nevertheless administered the aerosol. This occurred in 255 instances (33% of the decision points). Although the reasons for such inappropriate administration of the aerosols were not systematically recorded, in some cases the RT noted requests by the patient, parent, attending physician, or nurse that the aerosol be administered. There was a significant relationship between the number of aerosol treatments given inappropriately and the patient's initial clinical asthma score ($r = 0.26$, $p = 0.02$). There was also a significant relationship to the date of admission, with more frequent inappropriate aerosols having been administered earlier in the course of the trial ($r = 0.33$, $p = 0.005$). Aerosols were withheld inappropriately in 9 instances (2%). In each of these cases, aerosols were scheduled at 6-hour intervals but the aerosol was not administered because the patient was found to be in no distress. The protocol did not authorize the RT to administer aerosols less than every 6 hours.

Discussion

Previous studies have demonstrated that patient assessment and treatment programs implemented by RTs can facilitate cost-effective patient care either by decreasing delivery of unnecessary care or by decreasing length of stay, without deleterious effects on clinical outcomes.[8–11] However, there have been no previous reports of such a protocol applied to asthma patients. This project demonstrates the feasibility of using a standardized protocol to manage children hospitalized for status asthmaticus in a teaching hospital setting. Overall, the use of the protocol resulted in improved efficiency in the administration of β-agonist aerosols, compared with the traditional method, in which individual physicians' orders were required for each change in aerosol frequency.

Hypoxemia was not included as a criterion of respiratory distress in this protocol. In most patients with asthma, hypoxemia is caused by ventilation-perfusion mismatch due to airway obstruction and alveolar microatelectasis. As the asthma is treated with glucocorticoids and β-agonists, the hypoxemia usually resolves over the first several hours. However, in patients with coexisting pneumonia or larger areas of atelectasis, the alveolar disease resolves more slowly. These patients often require supplemental oxygen for 3 or more days. If the oxygen requirement were included as a criterion for β-agonist administration, these children would be receiving aerosol treatments every hour for several days, which would be exhausting for the patient and would not hasten his or her recovery. The criteria for respiratory distress in the protocol are considered to be sufficiently sensitive to ensure that patients with airway obstruction will receive treatment with a β-agonist. If the patient had hypoxemia with no other signs of airway obstruction, the physician was notified (Appendix 2, Number 6) so that the differential diagnosis could be reconsidered.

The first goal of this project, to develop standardized criteria for changing the frequency of β-agonist aerosols, was achieved by codifying objective criteria for respiratory distress. However, the correct application of these criteria depends on the ability of the RT to perform an accurate clinical assessment. In part, the successful adaptation of the RT service to this protocol was facilitated by the fact that a relatively small, stable group of therapists was assigned to the pilot unit. In other institutions where large numbers of RTs and RT trainees rotate among several different hospital units, familiarization of all the RTs with a new protocol would undoubtedly be more challenging. Frequent in-service training and routine competency testing of all personnel involved in the application of the protocol would be crucial for successful implementation.

One of the goals of this project was to determine the impact of the protocol on the frequency of β-agonist aerosol use. Although there was a significant reduction in aerosol use, there remains potential for further improvement. One third of the aerosols were given by the RT when no clinical signs of respiratory distress were documented. Aerosols were more likely to be given inappropriately to patients whose respiratory distress was more severe at the time of admission, probably due to a continuing perception of these patients as being in need of aggressive treatment. These occurrences were also significantly more frequent earlier in the trial period, implying that compliance improved as the staff became more familiar and, presumably, more comfortable with the protocol.

One of the chief concerns with the development and implementation of this protocol was to avoid any instances of inappropriately withholding β-agonist treatment. For this reason, the criteria for administration of the aerosol were conservative and the RTs were instructed to err on the side of over-treatment rather than under-treatment in questionable cases. In fact, on review of the RT documentation sheets, in every instance where the RT documented any sign of respiratory distress, the aerosol was administered. The only aerosol treatments that were inappropriately withheld during this study were those that were scheduled to be given at 6-hour intervals, but were not given because the patient was in no distress.

The length of hospital stay was not significantly different in the protocol group. It is common practice at our institution to discharge asthma patients from the hospital when they require β-agonist aerosols no more often than every 6 hours. The patients in the protocol group reached the 6-hour frequency significantly earlier than those in the control group. However, the discharge orders for the protocol patients were significantly delayed beyond this point, as compared with the control patients. This is partly attributable to the fact that 28 of the 71 control subjects were never weaned to the 6-hour aerosol frequency, but instead were discharged while receiving aerosols every 4 hours. Since the physician determined that these patients were ready for discharge, they were probably in no respiratory distress and would have been weaned to the 6-hour aerosol frequency if they had been on the protocol. Therefore, we do not have a true comparison of how long the patients in each group were kept in the hospital beyond the point where they were clinically stable and in no significant respiratory distress. This study did not focus on addressing the barriers relating to the decision to discharge, although there did not appear to be any relationship between the discharge delays and the patients' initial clinical asthma scores, ages, reversals in weaning of aerosol frequency, or dates of admission. Thus the effect of the protocol on length of hospital stay was minimal, but if other aspects of the discharge decision and logistics are addressed, there is potential for decreasing length of stay.

Some bias may have been introduced by the study design, which included two sequential time periods for the control and the protocol groups, rather than randomizing patients to the two groups during the same time frame. The intention of this study design was to avoid "contaminating" the treatment of the control group through familiarity of the medical team with the protocol. However, there might have been seasonal differences in the nature of the asthma episodes. The control group was enrolled during the late winter and spring, when asthma episodes were more likely triggered by viral infections. The protocol group was enrolled during the summer, when asthma episodes were more likely triggered by allergen exposure. However, the age and initial clinical severity of the two groups of patients were similar.

Conclusions

A protocol giving RTs increased autonomy in weaning β-agonist aerosols can reduce the number of aerosols required and the time from admission to discharge readiness for pediatric asthma patients in a teaching hospital. Continued improvement in implementation and outcomes of the protocol must be pursued through periodic reviews and retraining.

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APPENDIX 1

Asthma Care Flow Chart

Children's Hospital Medical Center

Time of Arrival, ED ______________
Time of Arrival, Floor ______________

Ht. ________ Wt. ___________

PEFR, personal best ______________
PEFR, 60% of predicted ____________

Upper limit respiratory rate for age __________

Allergies ____

Comments: ______________

ASTHMA CARE FLOW CHART

	Date/Time of Day (military time)	/	/	/	/	/	/	/	/	/	/	/	/
	PRE-tx or POST-tx												
	Oxygen Saturation (%)												
	FI02												
	Route/Flow Rate												
	RR												
	HR												
	Peak Flow												
Dyspnea	0 - None												
	1 - Mild												
	2 - Moderate												
	3 - Severe												
Accessory Muscles	0 - None												
	1 - one site												
	2 - two sites												
	3 - three sites or neck muscles												
Air Exchange	0 - Normal												
	1 - Slight decrease												
	2 - Moderate decrease												
	3 - Severe decrease												
Wheeze	0 - None												
	1 - End exp/or localized only												
	2 - Entire exp												
	3 - entire exp & inspr												
I:E Ratio	0 - 1:1.5												
	1 - 1:2.0												
	2 - 1:3.0												
	3 - >1:3.0												
	Albuterol Neb (mg)												
	Ipatropium Neb (ug)												
	Steroid mg/route	/	/	/	/	/	/	/	/	/	/	/	/
	Other Treatment												
	Initials												

Date of Discharge ____________
Time of Discharge ____________

signatures: ____________ ____________

Revised MRC 5/96

APPENDIX 2

β-Agonist Weaning Protocol

1. Albuterol, 0.5 to 1 mL in normal saline, is delivered by jet nebulizer at a flow rate of 7 L/min.

2. On the hospital wards outside the intensive care unit β-agonist aerosols can be given no more frequently than every sixty minutes. As the patient improves, the aerosol frequency is weaned through the following intervals: every 90 minutes, every 2 hours, every 3 hours, every 4 hours, and every 6 hours. The initial aerosol frequency is determined by the admitting physician based on the patient's clinical status. At the time of each scheduled aerosol, the respiratory therapist (RT) assesses the patient. If the patient shows any signs of respiratory distress, the aerosol is administered. The RT then returns at the same interval to assess the patient, and continues to give aerosols at this frequency as long as the patient continues to show signs of respiratory distress.

3. If the patient shows no signs of respiratory distress, the aerosol is withheld. The patient's clinical findings are documented on the Asthma Care Flow Sheet (see Figure 1), and the patient's nurse is notified of the decision to defer the aerosol. The RT returns to reassess the patient at the next interval; for example, if the aerosol was withheld at 90 minutes, the RT returns 30 minutes later, or 2 hours after the most recent aerosol treatment.

4. Once the patient is clinically stable on an aerosol frequency of every 6 hours, the patient is considered ready for discharge. β-agonist treatments are continued every 6 hours for the duration of the hospital stay.

5. The patient's nurse and the resident physician are to check the patient frequently. If any signs of respiratory distress develop prior to the next scheduled aerosol, the RT is notified and administers the aerosol. The interval between this and the previous aerosol becomes the scheduled interval for the next RT assessment; for example, if the aerosol frequency has been decreased to every 4 hours, but the nurse notes respiratory distress after 2 hours, the RT administers the aerosol and then reassesses and administers aerosol treatments every 2 hours thereafter, until the patient again shows no signs of respiratory distress.

6. The nurse or RT is asked to notify the physician if any of the following circumstances occur:
   - Increasingly severe respiratory distress.
   - β-agonist aerosol frequency increases to every 2 hours or less, after having been decreased.
   - Presence of increased respiratory rate and hypoxemia without signs of airway obstruction such as wheezing, prolonged expiratory phase, or increased work of breathing.
   - Adverse reactions to the β-agonist aerosol.

Oxygen Therapy Utilization in a Community Hospital: Use of a Protocol to Improve Oxygen Administration and Preserve Resources

Michael R Konschak MPH RRT, Adam Binder, and Ralph E Binder MD MPH

BACKGROUND: Medically unnecessary oxygen administration is believed to cause waste and substantial unnecessary costs. METHODS: We studied oxygen use at a community hospital before and after implementation of an oxygen use protocol designed to minimize unnecessary oxygen use, and calculated the savings. RESULTS: In the month before implementation of the protocol: 68% of the total oxygen use was found to be unnecessary; the median amount of oxygen wasted per patient was 10,800 L, and patients who received unnecessary oxygen received it for an average of 5.17 days each. After institution of the oxygen use protocol, unnecessary oxygen use was substantially reduced. The median amount of oxygen wasted per patient was reduced to 2,880 L, and patients who received unnecessary oxygen received it for an average of 78 days each. Fewer patients received oxygen unnecessarily and the median cost of wasted oxygen was reduced from $3.63 per patient to $1.15 per patient. CONCLUSIONS: Our results indicate that the yearly savings from implementing an oxygen protocol at our institution amount to at least $7915, improved appropriate use of oxygen therapy, and reduced the costs of inpatient care. [Respir Care 1999;44(5):506–511]

Key words: oxygen, resource utilization, oxygen therapy, therapist-directed protocol.

Introduction

The current health care environment demands that medically necessary care be given in an efficient and cost effective manner. Oxygen administration has not received the same attention as the administration of other therapeutic agents.[1,2] As a result oxygen is often given when not medically necessary or given in excess because patient response is not monitored.[3,4] In either case, medical care is administered inappropriately and resources are wasted. A less common but equally important problem is that inadequate oxygen therapy is given because patient response is not properly monitored. Additionally, oxygen administration protocols in the literature are often difficult to implement.[5–8]

With the goal of optimizing the medically appropriate and cost-effective use of oxygen, we studied these issues in a community hospital setting. We tested the hypotheses that oxygen is frequently used inappropriately at our hospital and that implementing an oxygen use protocol would reduce inappropriate oxygen use. We also determined the financial implications of inappropriate oxygen use.

Methods

The study was divided into 2 parts. The first part tested the hypothesis that oxygen is frequently used inappropriately. We included all patients (Group 1) in the noncritical care patient areas of Lawrence Hospital, Bronxville, New York. Current physician ordering practices and oxygen administration were not altered. For 1 month all hospital patients receiving oxygen were considered for inclusion in the study. Patients were excluded from the study only if they were admitted to the intensive care unit, were receiving mechanical ventilation, or if they presented with a condition affecting the peripheral circulation that would make pulse oximetry measurements inaccurate. The following information was obtained from medical records: sex, age, room number, medical record number, diagnosis, date of start of oxygen therapy, medical service ordering oxygen therapy, existence of baseline arterial blood gas or arterial oxygen saturation (S_{aO_2}) measurement, existence of a pulmonary consult, oxygen delivery device, and liter flow of oxygen.

Oxygen use was considered medically necessary if the S_{aO_2} measurement on room air was less than 92%. This value was chosen on the reasoning that any patient with an

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S_{aO_2} of 92% or higher would be clinically stable without oxygen. Some patients with an S_{aO_2} of 90% or 91% might not require oxygen, but this would require more clinical evaluation than we could perform during this study. With this liberal definition of appropriate oxygen use, we were sure not to deny oxygen to any patient who might possibly need it, but believed that even the liberal definition would still allow us to effectively test the hypothesis. The acceptable S_{aO_2} limit of 92% established for this study was actually conservative compared to the values considered acceptable by Blue Cross and Blue Shield,[9] in which guidelines for reimbursement require documentation of hypoxemia by an arterial oxygen tension (P_{aO_2}) of less than 60 mm Hg or an S_{aO_2} of less than 90%.

Pulse oximetry measurements were taken using a Nellcor N-10 Pulse Oximeter (Nellcor Puritan Bennett, Mallinckrodt Inc, Pleasanton, California). A reusable probe was placed on the patient's finger and an S_{aO_2} measurement obtained. If the S_{aO_2} was greater than or equal to 92%, the oxygen modality was temporarily removed from the patient and the S_{aO_2} was then continuously monitored for 10 minutes, carefully observing the patient for any clinical signs of desaturation (S_{aO_2} less than 92%). If after 10 minutes the S_{aO_2} was still greater than or equal to 92%, a second reading was taken after 30 minutes off of the oxygen modality. All three S_{aO_2} measurements were recorded. If the S_{aO_2} dropped below 92%, oxygen therapy was resumed, the liter flow was carefully titrated to achieve an S_{aO_2} value of 92% or greater, and this flow was recorded. Prior to leaving the patient's bedside, the oxygen therapy device was returned to the original ordered level. Patients were revisited every 48 hours and the oximetry procedure repeated until discharge from the hospital or upon a physician order to discontinue oxygen therapy. The total number of days using the oxygen modality was recorded for each patient. For patients in whom the initial oximetry measurement was less than 92%, the value was recorded and the patient's attending physician was immediately contacted for further instructions.

In the second part of the study we tested the hypothesis that implementation of a protocol for oxygen use would reduce inappropriate oxygen use and save money. We studied the effect of using an oxygen administration protocol (Fig. 1) on all patients in one patient area of the hospital (Group 2). This patient area had also been included in the first part of the study (Group 1 Subgroup). For 1 month all patients admitted to the hospital's telemetry unit who were receiving oxygen were considered for inclusion in the study. Exclusion factors and medical records information obtained for Group 2 were the same as for Group 1.

During the entire study, patients were continually observed by one of the authors and monitored via pulse oximetry during the oxygen titration process to prevent any possibility of significant oxygen desaturation.

Data were analyzed to determine the amount and cost of wasted oxygen for each group. A usage day was the use of oxygen by 1 patient for 1 day. Costs were calculated from actual costs to the hospital as follows: \$0.00023/L gaseous oxygen, \$1.78 per oxygen delivery device, changed every 48 hours. The cost of therapist time was not included in the calculation. Chi-square analysis was used to look for relationships between medically necessary oxygen use and the other parameters studied. Rank sums test was used to compare oxygen use and dollars wasted between the 2 study groups.

This study was performed after review by the Lawrence Hospital Critical Care Committee, the Respiratory Care Committee, and the Lawrence Hospital Medical Board.

Results

Table 1 shows the demographic characteristics of the study groups. Group 1 included all patients in the noncritical care patient areas of the hospital. Group 1 Subgroup includes the patients from Group 1 who were admitted to the telemetry unit of the hospital prior to the institution of the protocol (Group 1 Subgroup). Group 2 includes all the patients admitted to the telemetry unit of the hospital after the institution of the protocol for oxygen utilization. The number of patients in Group 2 is larger than the number in the Group 1 Subgroup because the data for Group 2 were collected in the winter (when the hospital was busy) and the data for the Group 1 Subgroup were collected in the summer (when the hospital was less busy). Chi-square analysis showed no significant differences between the groups with regard to sex or age on admission. There were more patients in Group 2 with a nonpulmonary diagnosis than in Group 1 or the Group 1 Subgroup, but this difference was not statistically significant.

Of the 164 patients considered for study in Group 1 (Table 2), 3 patients were excluded. Of the 161 patients studied, 53 were given oxygen appropriately and 127 received oxygen inappropriately. Nineteen patients are in both groups because they initially had an S_{aO_2} of less than 92% on room air, but subsequently had an improvement in S_{aO_2} and their oxygen therapy was continued. Medically necessary oxygen was given for 302 usage days during the month of study, and medically unnecessary oxygen was given for 657 usage days during the month of study.

During the pre-protocol month of study 2,459,880 L of oxygen were wasted. There was a wide range in the amount of oxygen wasted per patient. The median number of days of unnecessary oxygen use per patient was 3 (mean 5.17 days, range 1–19 days). The median amount of oxygen wasted per patient was 10,800 L (range 720–128,160 L). The total cost of this oxygen was \$743.62 during the month of study, or \$1.13 per usage day.

1. Obtain physician order for Oxygen Protocol. *Note*: This protocol will not be used if the patient is known to have an elevated P_{aCO_2} or if the patient has chronic obstructive pulmonary disease or an altered mental status, particularly lethargy. In these situations, oxygenation should be measured and F_{IO_2} adjusted using arterial blood gas analysis, since knowledge of the P_{aCO_2} and pH will then be needed for clinical management. If a patient with chronic obstructive pulmonary disease is known to have a normal P_{aCO_2} or a normal P_{aCO_2} is obtained upon arterial blood gas analysis, then further adjustments in F_{IO_2} can be made using the S_{aO_2} as a guide, as described below.

2. Prior to administering oxygen, obtain a pulse oximetry reading on room air. If the patient is already on oxygen, obtain the S_{aO_2} on oxygen. If the patient is in respiratory distress, administer oxygen and then obtain the S_{aO_2} on oxygen.

3. a) If the patient is tested on room air:

    i) If the S_{aO_2} is greater than or equal to 92%, do not administer oxygen

    ii) If the S_{aO_2} is less than 92%, administer oxygen and titrate the F_{IO_2} until an S_{aO_2} of at least 92% is obtained.

   b) If the patient is tested on oxygen:

    i) If the S_{aO_2} is greater than or equal to 92%, lower the F_{IO_2} or discontinue oxygen (if the F_{IO_2} is already less than 24% or 2 liters/minute via nasal canula), wait 30 minutes then repeat the S_{aO_2} measurement.

    ii) If the S_{aO_2} is less than 92%, titrate the F_{IO_2} until an S_{aO_2} of at least 92% is obtained.

4. An attempt should always be made to give the patient as little oxygen as needed to keep the S_{aO_2} greater than or equal to 92%.

5. This protocol will be repeated as the clinical situation changes.

6. Document results in the medical record.

Fig. 1. Oxygen Protocol

Table 1. Demographic Data of the Study Group

	Group One	Group One Subgroup	Group Two
Total Number of Patients	161	74	143
Males	64 (40%)	33 (45%)	58 (41%)
Females	97 (60%)	41 (55%)	85 (59%)
Average Age (years)	76	75	76
Diagnosis			
Pulmonary	51 (31%)	17 (23%)	19 (13%)
Cardiac	48 (30%)	40 (54%)	81 (57%)
Other	63 (39%)	10 (23%)	43 (30%)

Among the patients for whom oxygen was medically necessary, only 3 (6%) received too little oxygen and 9 (17%) received too much oxygen. In this group 20 patients (38%) were not wearing their oxygen when studied, while among those for whom oxygen was not medically necessary, 106 (83%) were not wearing the oxygen when studied. In this group of 106 patients the oxygen was just flowing out into the room.

Table 3 shows the relationships between the medically necessary use of oxygen and the parameters we studied. There was a significant relationship between measurement of baseline S_{aO_2} and a diagnosis of pulmonary disease and the appropriate use of oxygen. There was no relationship between the presence of an order for oxygen and medically necessary oxygen use. Patients who had a pulmonary physician as part of the health care team tended to receive oxygen appropriately, although this correlation was not statistically significant.

Of the 145 patients considered for study in Group 2 (Table 4), 2 patients were excluded. Of the 143 patients studied, 31 patients received oxygen appropriately and 112 patients received oxygen inappropriately during the protocol study period. This amounted to 90 usage days of

Table 2. Appropriateness of Oxygen Use Prior to Implementation of the Oxygen Protocol (Group 1)

Total number of patients studied	161
Number of patients in which oxygen was medically necessary	53*
Number of patients in which oxygen was not medically necessary	127
Number of days† in which oxygen was used and medically necessary	302 (32%)
Number of days in which oxygen was used but not medically necessary	657 (68%)
Median number of days of unnecessary oxygen use per patient (range)	3 (1–19)
Median number of liters of unnecessary oxygen per patient (range)	10,800 (720–128,160)
Median number of dollars wasted per patient (range)	$3.63 (0.99–31.44)

*19 patients initially had medically necessary oxygen, but continued to receive oxygen after they improved and no longer had a medical necessity for oxygen.
†1 day is the use of oxygen by 1 patient for 1 day.

Table 3. Relationship Between the Appropriate Use of Oxygen and Several Clinical Parameters

	Oxygen medically necessary	Oxygen not medically necessary
Total number of patients	53	127
Oxygen ordered by physician	50 (94%)	108 (85%)
Baseline S_{aO_2} measured	30 (57%)	37 (29%)*
Pulmonary physician on health care team	17 (32%)	25 (20%)
Diagnosis*		
Pulmonary disease	26 (49%)	29 (23%)
Other disease	27 (51%)	98 (77%)

*chi-square, $p < 0.005$; S_{aO_2} = arterial oxygen saturation.

medically necessary oxygen use and 87 days of medically unnecessary oxygen use. Most of the inappropriate oxygen use was for short periods of time. The median number of days of unnecessary oxygen use per patient was only 1 (range 0–7 days), the median amount of oxygen wasted per patient was 2,880 L (range 0–35,180 L), and the median number of dollars wasted per patient was $1.15 (range 0–$9.18). The average number of days that a patient received oxygen inappropriately was 0.78 days.

Table 4 also shows the data from a subgroup of Group 1 that applies to the same nursing unit as Group 2. This pre-protocol and post-protocol comparison is of patients from the same nursing unit at 2 different points in time. It gives a picture of the effect of the oxygen protocol on patient care in this unit. The total liters of oxygen wasted for the month prior to implementation of the protocol was 1,059,128, compared to 323,280 during the protocol. The cost of unnecessary oxygen delivery for the month prior to implementation of the protocol was $314.89, compared to $105.10 after implementation of the protocol. The number of usage days when oxygen was given inappropriately was much lower after institution of the protocol, and this difference was statistically significant. All of these differences underestimate the benefit of the oxygen use protocol, because there were more patients studied in Group 2 than in the subgroup of Group 1. There were statistically significant differences between these 2 groups in terms of days of unnecessary oxygen use per patient (3.87 days, 95% confidence interval [CI], 2.27–4.60 days), liters of unnecessary oxygen use per patient (15,294 L, 95% CI, 11,833–18,754 L), and dollars wasted per patient ($4.47, 95% CI, $2.98–$5.39).

We then estimated the yearly savings on the nursing unit where we studied oxygen therapy administration, both pre-protocol and post-protocol. In 1996, 688 patients were admitted to the unit. On average, 19 patients per day received oxygen. Prior to the protocol, 75% of the oxygen use days were unnecessary. After implementing the protocol there was a significant reduction in the number of days when oxygen was administered unnecessarily. The yearly savings for this unit was calculated to be approximately $2,477. A similar calculation for the entire hospital indicated an expected yearly savings of approximately $7915, based on actual costs.

Discussion

We found a substantial level of unnecessary oxygen use (68% of oxygen use days) in a community hospital. Although the costs associated with this unnecessary oxygen use are not dramatic, they are substantial, and the resources could be used to provide more appropriate respiratory care, which is increasingly important in that hospitals are now reimbursed by negotiated fees with managed care organizations or by Diagnosis-Related Groups from Medicare. We decided not to try to calculate the cost of therapist time to deliver the unnecessary oxygen, because this calculation could only have produced an estimate, while our cost data is an accurate accounting. We believe, however, that an oxygen protocol offers a definite savings in therapist time, because it takes much less time to obtain an oxygen saturation measurement to determine whether a patient needs oxygen than to set up an oxygen delivery device, monitor oxygen flow daily, and then remove the device. Therefore our calculated savings underestimate the true savings that could be obtained. We believe this is the case even though our equipment costs may have been relatively high because of the policy of changing oxygen delivery equipment every 48 hours. There are additional potential sav-

Table 4. Comparison of Appropriate Oxygen Use before and after Institution of an Oxygen Protocol

	Pre-protocol (Group 1 Subgroup*)	Post-protocol (Group 2)
Total number of patients studied	74	143
Number of patients in which oxygen was medically necessary	16	31
Number of patients in which oxygen was not medically necessary	58	112
Number of days† in which oxygen was used and medically necessary	92 (25%)	90 (51%)
Number of days in which oxygen was used but not medically necessary	271 (75%)	87 (49%)‡
Median number of days of unnecessary oxygen use per patient (range)	4 (1–16)	1 (0–7)§
Median number of liters of unnecessary oxygen per patient (range)	14,400 (2,880–84,960)	2,880 (0–35,280)§
Median number of dollars wasted per patient (range)	\$3.63 (1.15–23.46)	\$1.15 (0–9.58)§

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*Patients from Group 1 from the same nursing unit studied in Group 2 were used for this comparison.

†1 day is the use of oxygen by 1 patient for 1 day.

‡chi-square, $p < 0.001$.

§Rank sums, $p < 0.0001$.

ings if the initial evaluation is done by the nursing staff as they measure other vital signs when a patient first arrives. The measurements can then easily be repeated when the clinical situation changes.

Previous research has not calculated actual costs. Estimates have been made based on dollar amounts billed or charged, or on the estimated cost of lost or occupied therapist time. In a review of 170 patient oxygen orders made during a 1-month period, Kester and Stoller[5] concluded that 25.2% of the orders were not indicated, resulting in unnecessary charges of \$11,937, as well as occupied therapist time. Akpunonu et al[10] observed in their study of a 3-month period that patients were improperly billed a total of \$25,880. When extrapolated, these numbers predict tremendous savings, but they do not reflect actual costs and therefore do not help to develop more efficient use of health care resources.

Previous studies have documented the use of oxygen when not clinically indicated. Brougher et al[3] reported that 38% of oxygen orders failed to meet clinical or physiologic indications for treatment. Small et al[1] reported that that 23% of orders for oxygen were for use on an as-needed basis and that orders for oxygen were more haphazard than those for other therapeutic interventions such as antibiotics.

Our results clearly show that oxygen is over utilized at our institution and that oxygen is ordered for the great majority of patients (85–94%). Baseline measurement of S_{aO_2} is made in only 29–57% of cases, but we identified a significant relationship between the measurement of baseline S_{aO_2} and the appropriate use of oxygen. This supports the idea that when S_{aO_2} is known, physicians will tend to order oxygen only if it is medically necessary. Similarly, we found that oxygen was used more appropriately in patients diagnosed with pulmonary disease than with other diagnoses. This probably reflects the fact that patients with pulmonary disease are more likely to require oxygen and physicians may be more likely to order a baseline S_{aO_2} measurement in these patients. There was a tendency for oxygen to be used more appropriately with patients who had had a pulmonary consult, but, surprisingly, this relationship was not statistically significant.

We might have overestimated the value of our oxygen administration protocol if there were significant demographic differences between Group 1 and Group 2. There were more patients with nonpulmonary diagnoses in Group 2, but these differences were not statistically significant. Since patients with a nonpulmonary diagnosis were more likely to receive oxygen inappropriately, this difference between the groups would have lessened the differences we observed. The larger number of patients in Group 2 was because of a seasonal difference in hospital occupancy. This difference would tend to cause an underestimate of the dollar savings of the oxygen protocol. Thus, we believe that the comparison between Group 2 and the Group 1 Subgroup (see Table 4) underestimates the potential benefits of an oxygen protocol.

Our protocol was designed to be simple to use and administer. Some previously published protocols have been complicated and involved so many steps that their use added significant time to the care-giving process.[5–8] Because our protocol is simple, we realize that it might not be appropriate for certain patients. Patients with underlying chronic lung disease, who may have carbon dioxide retention, will need arterial blood gas analysis to monitor their need and use of oxygen, though if an initial arterial blood gas measurement shows normocapnia, this protocol could be used selectively in these patients. Additionally, we arbitrarily but deliberately used a liberal value for oxygen saturation to determine appropriate oxygen use (so as to be certain that we did not deny oxygen to patients who truly needed it). The guidelines for home use of oxygen are stricter than those we applied, and certainly one could choose a lower S_{aO_2} value for in-hospital use as well. Such a lower cutoff for S_{aO_2} would further enhance the potential savings and waste reduction.

The use of pulse oximetry in this study is justified by experience previously reported.[11] Mahlmeister et al[12] reported on the usefulness of this modality in nursing care. King and Simon[6] concluded that substituting pulse oximetry for arterial blood gas analysis would reduce days of oxygen use, improve patient comfort, and save money by reducing costs. Similar findings from Inman et al[13] and Albin et al[4] support the idea that pulse oximetry can be used to monitor supplemental oxygen in hospitalized patients, and it is used routinely in anesthetic practice for this purpose.[14,15] It has been suggested[16] that we should make pulse oximetry a "fifth vital sign," joining blood pressure, heart rate, respiratory rate, and temperature as a routine nursing measurement.

Conclusions

We found that implementation of a simple oxygen protocol reduced the administration of unnecessary oxygen. Our data show a dramatic reduction in the inappropriate use of oxygen and substantial savings deriving from that reduction. However, even during the second part of our study, oxygen was initially given when not needed. This fact stems from the design of the study, in that we were called to evaluate patients after they had been admitted and initial orders were written. Thus, inappropriate oxygen was often underway when the protocol was begun. If the protocol were part of the initial orders and nursing evaluation, then unnecessary oxygen use would be further reduced, and the dollar savings would easily pay for the oximeters needed to perform the measurements. Additionally, the time saved in setting up and taking down unnecessary oxygen modalities would easily offset the added time of taking the oximetry measurements. Most important, however, is that we would then be administering oxygen with the same care and diligence that we apply to other therapeutic interventions, which is an important goal. In addition to providing appropriate care in an efficient manner, our behavior affects that of our patients. They will eventually also view oxygen with the respect it deserves, and learn that it is administered by justified need, not haphazardly whenever one has a respiratory symptom.

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Monitoring Quality in a Respiratory Care Protocol Service: Methods and Outcomes

Lucy Kester RRT MBA and James K Stoller MD

BACKGROUND: A respiratory therapy consult service (RTCS) was initiated at The Cleveland Clinic Foundation in 1992, and has directed respiratory care for most adult non-ICU inpatients since December 1994. In 1996 an audit system was initiated to study the timeliness and appropriateness of the respiratory care plans being written and implemented. METHODS: Two care plans per week were audited by the education coordinator. The auditor's assessment is conducted within 24 hours of the therapist's initial assessment, and without knowledge of the therapist's assessment or care plan. These independently-created assessments were compared, and feedback was provided to the therapist. Audit results were presented and discussed quarterly during respiratory therapy section administrative meetings, and were posted for review by respiratory care staff. RESULTS: During the first 8 quarters of the audit system, agreement on assessment items and respiratory care modalities was consistently high, though with greater agreement on respiratory care modalities than assessment items. The percentage of agreement on care plans improved during the first 8 quarters. Adjustments designed to minimize the subjectivity of certain assessment categories improved the percentage of agreement in assessments. CONCLUSIONS: An audit system can help improve the accuracy and timeliness of a respiratory care protocol service, serve as an educational tool, and promote therapists' best efforts. [Respir Care 1999; 44(5):512–519] *Key words: protocols, monitoring, quality control, respiratory therapy consult service, patient assessment.*

Introduction

The use of respiratory care protocols in acute care hospitals has been steadily increasing over the last decade. In a 1995 American Association for Respiratory Care survey[1] (1,892 respondents) 40% of the responding hospitals were currently using respiratory care protocols, 18% were in the process of implementing protocols, and 24% were familiar with protocols and were considering their use. The Lewin Group[2] reported that respiratory care protocols are also being used in subacute care, skilled nursing facilities, and home care. Numerous reports have indicated the effectiveness of individual protocols in reducing both costs and misallocation of respiratory services, and several studies have documented the cost effectiveness of using a comprehensive protocol program.[3–5] However, little information is available regarding the ongoing monitoring of the correctness, appropriateness, or quality of the respiratory care assessments and the care plans generated in protocol programs.

The Cleveland Clinic Foundation has utilized a comprehensive respiratory therapy consult service (RTCS) since 1992.[6–8] The process for this service is as follows:

1. A physician orders a respiratory therapy consult or a specific respiratory therapy service.
2. The unit secretary enters the order into the computerized order entry system.
3. The computer system notifies respiratory therapy office of the order.
4. A therapist evaluator performs a patient assessment and writes a respiratory therapy care plan.
5. The indicated therapy is implemented by the evaluator or the therapist covering the nursing unit.

Once the RTCS was established on all nursing units and initial operational problems were resolved, we established a method for monitoring the quality of the respiratory care plans and improving the performance of the program. We implemented an audit system that provides information to the manager, supervisors, and therapist evaluators regarding the appropriateness of respiratory care plans.

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Methods

Two respiratory care plans per week are audited by the education coordinator, who sees the patient within 24 hours following the therapist evaluator. The auditor writes a care plan based only on the clinical information that was available to the therapist evaluator at the time of the initial assessment. Both the therapist evaluator and the auditor conduct patient assessments using a triage rating system that includes 8 patient assessment categories, laboratory data, pulse oximetry, and vital capacity measurements. Figure 1 shows the form used in preparing the assessment. Prior evaluation of this triage rating instrument has shown that it is both valid and reliable in evaluating patients' respiratory care needs for an RTCS.[9] During the assessment process, indications for therapy are observed and checked on the care plan form (Fig. 2). A care plan is then written following the corresponding algorithms for each indicated therapy. Upon completion of the auditor's care plan, a comparison is made with the therapist evaluator's care plan for agreement or disagreement on each of the 8 assessment categories, as well as each of 6 respiratory care treatment modalities (eg, bronchodilators and oxygen). Information from the comparison is entered on a performance improvement reporting sheet (Fig. 3) for use by the respiratory therapy manager, and on a therapist evaluator feedback form (Fig. 4). The therapist evaluator feedback form is placed in the evaluating therapist's mailbox within 48 hours of the assessment. In addition to the percent agreement on the assessment categories and the treatment modalities, data are collected regarding the care plan form completeness (indications checked, time, date, and triage score recorded), evaluation timeliness (within 8 hours of the order), and the correct frequency of the therapies (according to a table that relates frequency to triage number). Audit results for the 24 patients sampled each quarter are presented and discussed during the respiratory therapy section administrative meetings (which include the medical director, manager, and supervisors), and are posted in the report room for review by the respiratory therapy staff.

Results

Table 1 presents the results from the first 8 quarters (March 1996 through March 1998) of our experience in rating percent agreement on assessment categories and care plan items. The percent agreement on assessment categories and respiratory care plan treatment modalities are consistently high across quarters. There was greater agreement on care plan items than assessment categories. Among the 8 triage score axes, disagreement was uncommon, but most frequent (16.6%) regarding pulmonary status. Among treatment modalities, disagreement between the therapist evaluator and the auditor was infrequent, but most frequent (14.4%) regarding hyperinflation.

Table 2 shows the percent of care plans that were complete, timely (ie, written within 8 hours of the order), and had correct frequencies. The percentage of timely care plans appeared to be improving over time, except during Quarter 7. The percentage of complete care plans ranged between 58% and 100%. The percentage of correct frequencies ranged between 75% and 92%.

Discussion

Along with assuming the responsibility for performing patient assessments and writing respiratory therapy care plans, respiratory care managers must assure the quality of respiratory therapists' assessments and care plans. To accomplish this, the Respiratory Therapy Section of the Department of Pulmonary and Critical Care Medicine at The Cleveland Clinic Foundation implemented the respiratory care plan audit system described above. This system enables therapists and administrative staff to assess the performance of individual therapist evaluators and the overall performance of the RTCS, and to identify weaknesses in the assessment and care plan areas.

The consistently high agreement between therapist evaluators and the auditor for triage score categories and respiratory care modalities probably reflects the use of a structured assessment form and care plan writing process that includes algorithms to determine delivery methods for specific modalities and, thus, guides therapists in decision-making.

The percentage of timely (written within 8 hours of the consultation request) care plans per quarter improved until Quarter 6, when it decreased slightly (4%). In Quarter 7 timeliness decreased 9%. However, there were 15% more consults during Quarter 7 than during Quarter 6 (1,954 during Quarter 7 versus 1,695 during Quarter 6), and we speculated that the increased volume of consults contributed to the decrease in timeliness. To accommodate the increased number of consults, an additional therapist was assigned to consult evaluations at the beginning of Quarter 8. The percent timely returned to 96% in Quarter 8, despite the fact that the number of consults during Quarter 8 was even higher than during Quarter 7 (1,979 during Quarter 8). We believe the higher timeliness rating during Quarter 8 reflects the increase in staff assigned to perform consult evaluations.

Ratings for the percent of complete care plans and the percent of correct frequencies fluctuated, probably reflecting the performance of new evaluators with less experience in completing the consult form and who sometimes forget to check the frequency table.

When examining the triage score axis with the highest percent of disagreement (pulmonary status), we found that

CCF RESPIRATORY THERAPY EVALUATION

DATE: ________________ **HT:** ______

TIME: ________________ **AGE:** ______

DIAGNOSIS: ________________________________

RESPIRATORY THERAPIST: ____________________

CHART ASSESSMENT

Points	0	x	1	x	2	x	3	x	4	x	Points
Pulmonary Status	(-) History (-) Smoking		Smoking history < 1 pk a day		Smoking history ≥ 1 pk a day		Pulmonary disease (acute or chronic)		Severe or chronic with exacerbation		
Surgical Status	No surgery		General Surgery		Lower abdominal		Thoracic or upper abdominal		Thoracic with pulmonary disease		
Chest x-ray	Clear or not indicated		Chronic radio-graphic changes		Infiltrates, atelectasis, or pleural effusions		Infiltrates in more than one lobe		Infiltrate + atelectasis and/or pleural effusion		

LAB TEST: Date: WBC ___ Hb ___ Pts ___	Date	pH	PaCO2	PaO2	HC03	Sat / FiO2

PULMONARY FUNCTION TEST: Minimal Pred. VC ______________ VC __________ Peak Flow __________	SpO2 / FiO2	Vital Signs: HR ___ BP ___ RR ___ Temperature (24 hr. max.) _______

Points	0	x	1	x	2	x	3	x	4	x	Points
Respiratory Pattern	Regular pattern, RR 12-20		Increased RR 21-25		Dyspnea on exertion, irregular pattern RR 26-30		Decreased vital capacity * RR 31-35		Severe SOB, use of accessory muscles RR > 35		
Mental Status	Alert, oriented, cooperative		Lethargic, follows commands		Confused, does not follow commands		Obtunded		Comatose		
Breath Sounds	Clear to auscultation		Decreased unilaterally		Decreased bilaterally		Crackles in the bases		Wheezing and, or rhonchi		
Cough	Strong, spontaneous, non-productive		Strong, productive		Weak, non-productive		Weak productive, or weak with rhonchi		No spontaneous cough or may require suctioning		
Activity Level	Ambulatory		Ambulatory with assistance		Non-ambulatory		Paraplegic		Quadriplegic		

* VC < or = to minimal predicted:

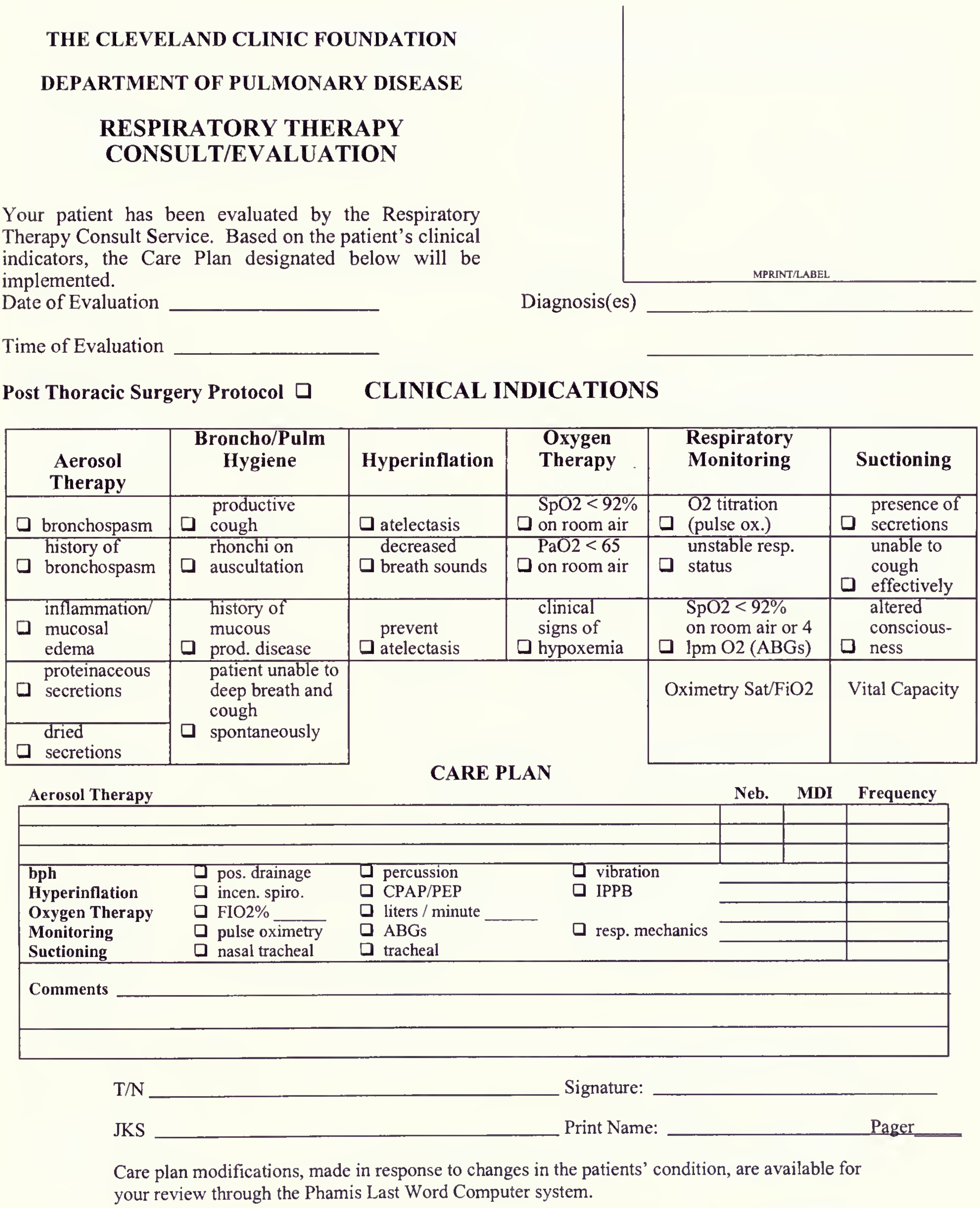
Predicted Ideal Body Weight
(Males: 50 + (2.4 x inches > 60)
(Females: 45 + (2.4 x inches > 60)
Multiply above ideal body wt. x 15 cc for min. pred. VC

Total Points ☐

Triage # ☐

TRIAGE 1	TRIAGE 2	TRIAGE 3	TRIAGE 4	TRIAGE 5
> 20	(16-20)	(11-15)	(6-10)	(0-5)

Fig. 1. An evaluation form for guiding a standardized patient assessment and assigning a severity of illness (triage) score. The triage score is used to determine the frequency of therapy.



THE CLEVELAND CLINIC FOUNDATION

DEPARTMENT OF PULMONARY DISEASE

RESPIRATORY THERAPY CONSULT/EVALUATION

Your patient has been evaluated by the Respiratory Therapy Consult Service. Based on the patient's clinical indicators, the Care Plan designated below will be implemented.

MPRINT/LABEL

Date of Evaluation ____________________

Time of Evaluation ____________________

Diagnosis(es) ______________________________

____

Post Thoracic Surgery Protocol ☐

CLINICAL INDICATIONS

Aerosol Therapy	Broncho/Pulm Hygiene	Hyperinflation	Oxygen Therapy	Respiratory Monitoring	Suctioning
☐ bronchospasm	☐ productive cough	☐ atelectasis	☐ SpO2 < 92% on room air	☐ O2 titration (pulse ox.)	☐ presence of secretions
☐ history of bronchospasm	☐ rhonchi on auscultation	☐ decreased breath sounds	☐ PaO2 < 65 on room air	☐ unstable resp. status	☐ unable to cough effectively
☐ inflammation/ mucosal edema	☐ history of mucous prod. disease	☐ prevent atelectasis	☐ clinical signs of hypoxemia	☐ SpO2 < 92% on room air or 4 lpm O2 (ABGs)	☐ altered consciousness
☐ proteinaceous secretions	☐ patient unable to deep breath and cough spontaneously			Oximetry Sat/FiO2	Vital Capacity
☐ dried secretions					

CARE PLAN

Aerosol Therapy	**Neb.**	**MDI**	**Frequency**

bph	☐ pos. drainage	☐ percussion	☐ vibration		
Hyperinflation	☐ incen. spiro.	☐ CPAP/PEP	☐ IPPB		
Oxygen Therapy	☐ FIO2% ______	☐ liters / minute ______			
Monitoring	☐ pulse oximetry	☐ ABGs	☐ resp. mechanics		
Suctioning	☐ nasal tracheal	☐ tracheal			

Comments ____

T/N ________________________________ Signature: ______________________

JKS ________________________________ Print Name: ______________________ Pager_____

Care plan modifications, made in response to changes in the patients' condition, are available for your review through the Phamis Last Word Computer system.

Fig. 2. A care plan form for recording the patient's indications for respiratory therapy and the therapeutic modalities for treating the indications.

PERFORMANCE IMPROVEMENT MONITORING CONSULT SERVICE

Date: ____________ Time: ______ Clinic Number: __________

Age: ____________ Sex: ______ [ ] Male [ ] Female

Location: ______________________________

Diagnosis: ______________________________

Ordering Service: ______________________________

Timeliness:

1. Time elapsed between order and evaluation is less than 8 hours. [ ] Yes [ ] No

Correct Triage Sheet:

2. Triage evaluation sheet correct (± 2 total points). [ ] Yes [ ] No

Indications for Ordered Therapy:

3. Indications existed for all ordered therapy. [ ] Yes [ ] No

List errors: ______________________________

____

Therapy for all Indications:

4. All indications had appropriate therapy ordered. [ ] Yes [ ] No

List errors: ______________________________

Frequencies:

5. Frequencies correlated with triage score. [ ] Yes [ ] No

List exceptions: ______________________________

____

6. Care Plan Documentation:
Care plan was complete. [ ] Yes [ ] No

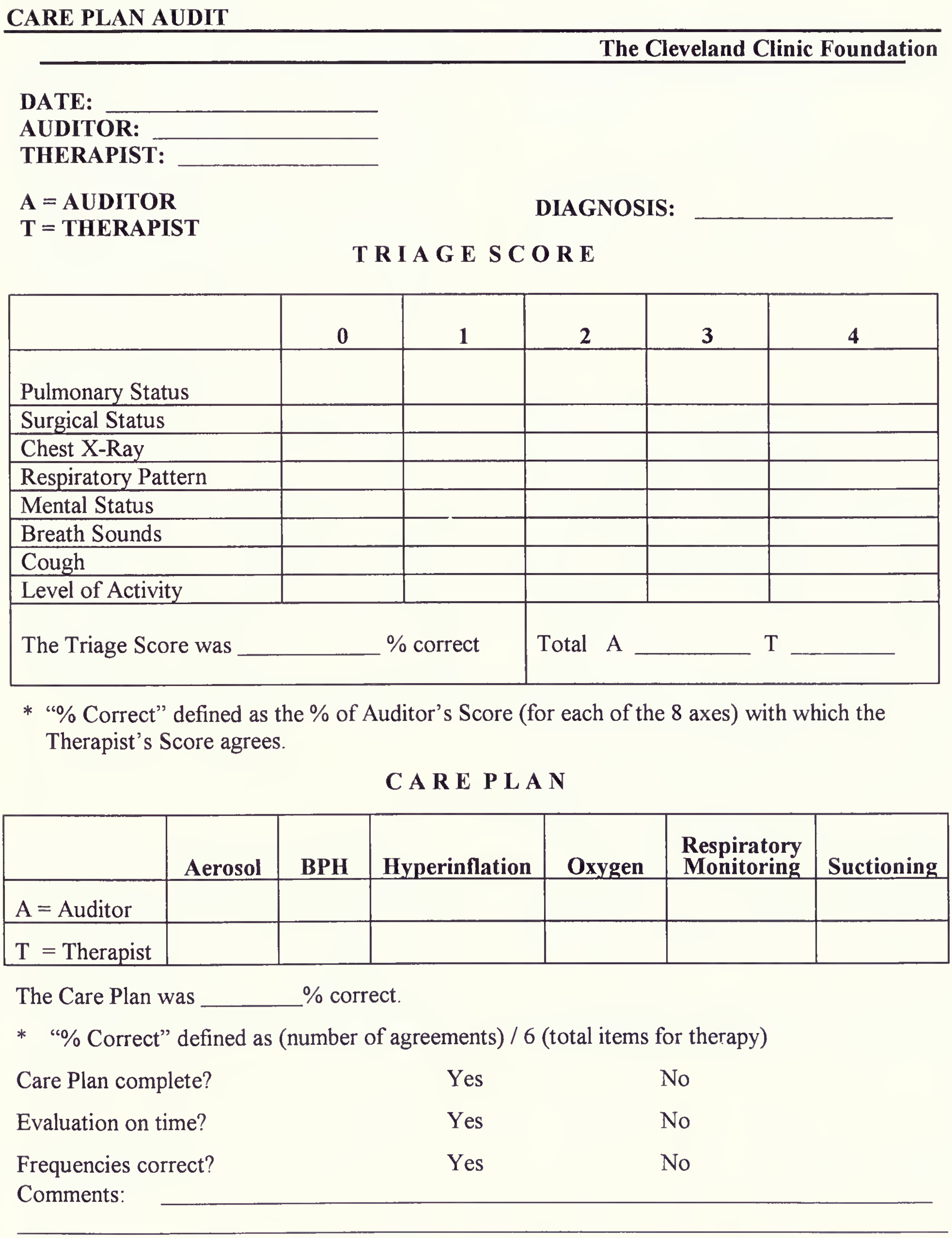
Circle error: date, time, indications checked, care plan recorded correctly, signature, triage number.

Comments: ______________________________

____

EMPLOYEE CODE NUMBER: ____________ OBSERVER: ____________

Fig. 3. A data collection form for monitoring performance improvement in a respiratory therapy consult service.



CARE PLAN AUDIT

The Cleveland Clinic Foundation

DATE: ____________________
AUDITOR: ________________
THERAPIST: ______________

A = AUDITOR
T = THERAPIST

DIAGNOSIS: ______________

TRIAGE SCORE

	0	**1**	**2**	**3**	**4**
Pulmonary Status					
Surgical Status					
Chest X-Ray					
Respiratory Pattern					
Mental Status					
Breath Sounds					
Cough					
Level of Activity					
The Triage Score was __________ % correct			Total A _________ T _________		

* "% Correct" defined as the % of Auditor's Score (for each of the 8 axes) with which the Therapist's Score agrees.

CARE PLAN

	Aerosol	**BPH**	**Hyperinflation**	**Oxygen**	**Respiratory Monitoring**	**Suctioning**
A = Auditor						
T = Therapist						

The Care Plan was ________% correct.

* "% Correct" defined as (number of agreements) / 6 (total items for therapy)

Care Plan complete?	Yes	No
Evaluation on time?	Yes	No
Frequencies correct?	Yes	No

Comments: ____

Fig. 4. A form for providing feedback to therapist evaluators regarding their patient assessment and care plan writing performance. An A (auditor) and a T (therapist) in the same triage scoring box or therapeutic category indicates agreement.

Table 1. Percent Agreement on Assessment Items and Respiratory Care Modalities

Quarter	% Agreement on triage score items	% Agreement on treatment modalities
1	83.5	91.2
2	86.9	93.1
3	86.7	96.5
4	88.5	95.8
5	92.2	93.8
6	92.7	95.8
7	91.7	95.8
8	91.1	96.5

n = 187 Audits (19 for Quarter 1, 24 for Quarters 2–8)

evaluators were not consistent when scoring the frequently utilized "rule out pneumonia" diagnosis. After clarifying this category (ie, the patient is considered to have pulmonary disease if the "rule out pneumonia" is accompanied by an infiltrate and a decrease in oxygenation), the number of disagreements decreased from 4.7 per quarter to 1.5 per quarter. The category with the second highest percent of disagreement on triage score axes was breath sounds. The somewhat subjective nature of this category, along with the fact that breath sounds tend to change over a short period of time, might explain the high frequency of disagreement.

The care plan item on which the therapist evaluators and the auditor disagreed most frequently was hyperinflation. This category includes incentive spirometry, intermittent positive pressure breathing, and continuous positive airway pressure positive expiratory pressure therapy. Disagreement occurred most often when the patient was unable to perform a vital capacity maneuver (making it difficult to determine the need for intermittent positive pressure breathing), and in defining "ambulating with assistance" (which is tied to the use of incentive spirometry to prevent atelectasis). When the processes for rating these situations were better defined, the rate of disagreement for hyperinflation decreased from 4.3 per quarter to 1 per quarter.

As an operational aspect of this study, the therapist evaluator feedback form (see Fig. 4) has several advantageous features. First, the comment section at the bottom of the form allows the education coordinator to explain reasons for disagreement; thus, the form serves an educational function for the therapists and promotes discussion between the therapist evaluators and the education coordinator. Supervisors are able to use the information from an individual therapist's care plan audits as part of each therapist's performance appraisal. Because the audit system conveys the importance of high quality patient assessments and care plans, the therapist evaluators have a heightened sense of the importance of the RTCS and an increased desire to put forth their best performance. As one therapist evaluator expressed it, "I write my care plans as though the education coordinator is looking over my shoulder."

Several limitations of this study warrant mention. First, because the sample size is small (only 1.3% of all quarterly consults are sampled), it is possible that our sample is not representative of all consults. Second, in an effort to assure appropriateness of care, the tendency is to monitor the less experienced therapist evaluators, thus skewing the results toward lower percent agreement. Specifically, approximately 50% of the audits are performed on newer, less experienced therapist evaluators who complete only a small percentage (approximately 12%) of the total number of consult evaluations. Third, a change in patient status may occur during the 24-hour lag time between the therapist evaluator's assessment and the auditor's assessment, which can lead to disagreement in assessment categories. Finally, some of the disagreement in assessment categories may reflect the subjectivity of assessing certain patient characteristics such as cough effectiveness.

Conclusions

Implementing an ongoing audit process is an important step to assure quality and intertherapist concordance in an RTCS. Results from 8 quarters of audits in our RTCS suggest a high frequency of agreement between the auditor and the therapist evaluators regarding patient assessment ratings and care plan modalities. By using such an audit system, areas of weakness within the consult process can be identified and remedied. Feedback from the audits serves as an educational tool and helps to promote therapist evaluators' best efforts.

Table 2. Percent of Care Plans That Were Complete, Timely, and Had Correct Frequencies

Quarter	1	2	3	4	5	6	7	8	Average
Complete	89	79	67	79	100	75	75	58	77.5
Timely	68	79	83	88	96	92	83	96	86.1
Correct Frequency	89	92	83	92	92	75	83	83	86.1

Complete = Included: date, time, indications, signature, triage number; Timely = Complete within 8 hours of the order; Correct frequency = Agreeing with triage number frequency chart.

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Inspiratory Time, Pressure Settings, and Site of Supplemental Oxygen Insertion Affect Delivered Oxygen Fraction with the Quantum PSV Noninvasive Positive Pressure Ventilator

Jonathan B Waugh PhD RRT and Randy M De Kler MS RRT

BACKGROUND: With noninvasive positive pressure ventilation (NPPV), the fraction of delivered oxygen (F_{DO_2}) can change if other ventilatory parameters are altered, but the extent and precise nature of the relationship between F_{DO_2} and other ventilatory parameters is not well understood. METHODS: We studied a new NPPV device, the Quantum PSV (Respironics Inc, Marietta, Georgia) to measure changes in the F_{DO_2} with changes in 4 ventilatory parameters: (1) inspiratory pressure, (2) expiratory pressure, (3) inspiratory time fraction (T_I), and (4) insertion point of supplemental oxygen. RESULTS: Each oxygen L/min increase yielded a 0.05–0.06 increase in the oxygen concentration delivered to the test lung. Changing the site of oxygen introduction resulted in a 0.04–0.10 increase in mean F_{DO_2}. Comparing mean F_{DO_2} values from both oxygen introduction sites yielded p-values < 0.001 for each level of O_2 flow. Oxygen at CPAP levels of 4 and 10 cm H_2O produced mean F_{DO_2} values of 0.71 and 0.48 respectively at 10 L/min O_2, and 0.98 and 0.70 at 15 L/min O_2. When data from all 4 inspiratory positive airway pressure-expiratory positive airway pressure (IPAP-EPAP) combinations were pooled, F_{DO_2} was significantly higher with $T_I = 0.25$ than with $T_I = 0.35$ ($p < 0.001$). Within each IPAP-EPAP level (10 and 15 cm H_2O), all 3 pairs were different, yielding p-values < 0.001. CONCLUSIONS: Altering T_I and EPAP level (while maintaining a constant pressure gradient) both significantly changed F_{DO_2}. Introducing oxygen into the patient circuit at the point most distant from the patient (nearest to the ventilator) provided higher F_{DO_2} values than when oxygen was inserted near the mask, but adding oxygen at the distal site is not advisable in that it might increase fire hazard. Clinicians should be aware that during NPPV, changing ventilator control settings can significantly alter F_{DO_2}. [Respir Care 1999;44(5):520–523] *Key words: noninvasive ventilation, NPPV, supplemental oxygen therapy, bench studies.*

Introduction

Noninvasive positive pressure ventilation (NPPV) is becoming common in the clinical setting, and is being used with an increasing variety of patient types.[1–4] A typical use of NPPV is the unloading of respiratory muscles during an exacerbation of chronic obstructive pulmonary disease,[5] but the capacity to provide an increased fraction of delivered oxygen (F_{DO_2}) is also useful in other patients. These patients can be quite sensitive to the amount of oxygen delivered, so it is important to know how changes in application of oxygen and changes in ventilator settings administered through an NPPV device alter F_{DO_2}. Few noninvasive ventilators have oxygen controls, so practitioners typically "bleed-in" 100% oxygen to the inspiratory circuit at some point downstream of the ventilator output (primarily to keep high concentrations of oxygen away from the electric turbine blower that generates air flow for pressurized breaths).

Respiratory care practitioners are accustomed to changing closed-system ventilator parameters such as pressure, volume, inspiratory time fraction (T_I), and positive end-expiratory pressure without concern for altering the oxygen delivered to the patient. With NPPV, however, changes to these ventilatory parameters effect F_{DO_2}, so it is important to understand how changing various ventilator controls affects oxygen delivery with NPPV, and to know the approximate F_{DO_2} range that can be expected from NPPV devices. We hypothesized that the location of the supple-

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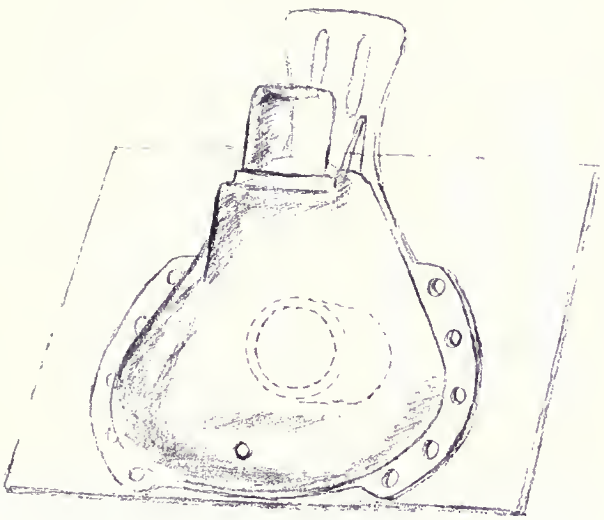

Fig. 1. Patient mask with lung model adapter.

mental oxygen insertion point in the inspiratory circuit would affect F_{DO_2}. We measured the effect on F_{DO_2} of manipulating the flow, supplemental oxygen insertion point, T_I, expiratory positive airway pressure (EPAP), and inspiratory positive airway pressure (IPAP), using a new pressure support-type NPPV device, the Quantum Pressure Support Ventilator (Quantum PSV) (Respironics Inc, Marietta, Georgia).

Methods

The Quantum PSV is a noninvasive ventilator that provides spontaneous (patient-triggered) and/or timed modes of pressure support, as well as continuous positive airway pressure (CPAP) mode. The first set of measurements varied the supplemental oxygen flow over a range of 1 to 10 L/min with the constant settings of: rise time = 0.5 seconds; $T_I = 0.25$; IPAP = 27 cm H_2O; EPAP = 2 cm H_2O; and breaths per minute (f) = 10. The adjustment of rise time determines the rate of change in pressure from EPAP to IPAP, with 0.5 seconds representing the middle value of the range. The manufacturer's breathing circuit and nasal mask were used, with the open end of the mask adapted to fit a standard 22 mm connector (Fig. 1); this was important because the bleed-hole for expired carbon dioxide was integral to the mask. The mask adapter was connected to a Manley test lung (Ohmeda Inc, Madison, Wisconsin) set at a system compliance of 50 mL/cm H_2O and an airway resistance of 2.0 cm $H_2O/L{\cdot}s$.

The mean F_{DO_2} ([high value + low value]/2 at each level) was measured between the nasal mask and the test lung using a Mini Ox O_2 analyzer (MSA Medical Products, Pittsburgh, Pennsylvania) with an in-line sampling connector (Fig. 2). Oxygen was delivered at various flows (2, 4, 6, and 10 L/min) and was added to the patient circuit either next to the patient mask or next to the ventilator outlet. The lung model and patient circuit were flushed with room air between each increase in supplemental oxygen flow and change in bleed-in site. Each level of oxygen flow was maintained for 2 minutes to allow the F_{DO_2} reading to stabilize before recording four successive measurements.

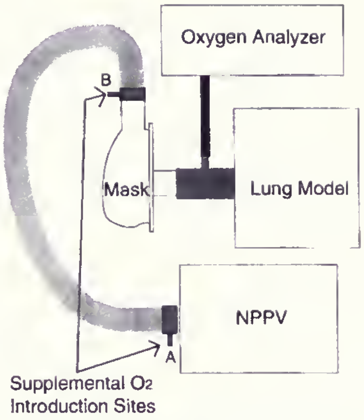

Fig. 2. Schematic diagram of measurement setup. NPPV = noninvasive positive pressure ventilator.

The second set of measurements used the same test setup, with the oxygen flow first set at 10 L/min, T_I set at either 0.25 or 0.35, and at four different IPAP-EPAP combinations: (1) IPAP at 12 cm H_2O and EPAP at 2 cm H_2O; (2) IPAP at 17 cm H_2O and EPAP at 2 cm H_2O, (3) IPAP at 22 cm H_2O and EPAP at 2 cm H_2O, and (4) IPAP at 27 cm H_2O and EPAP at 2 cm H_2O.

To determine whether a different baseline pressure (EPAP) resulted in a different F_{DO_2}, two IPAP-EPAP levels yielding pressure gradients of 10 and 15 cm H_2O were generated with three different IPAP-EPAP combinations. Quantum PSV settings were f = 10, $T_I = 0.25$, and rise time = 0.5 seconds. Measurements for both IPAP-EPAP pressure gradients were made during delivery of supplemental oxygen at 10 L/min, with the same test lung settings as before. Finally, we measured the consequent F_{DO_2} from supplemental oxygen (10 L/min and 15 L/min) introduced near the ventilator at CPAP levels of 4 or 10 cm H_2O with a spontaneous f of 10 and an externally-generated tidal volume (V_T) of 300 mL. Spontaneous breaths were generated by moving the test lung bellows to a fixed bar marker on the volume scale of the device, in synchrony with an electronic timer.

Results

Fraction of Delivered Oxygen Range Obtained with Supplemental Oxygen

Figure 3 shows the mean F_{DO_2} associated with each level of supplemental oxygen flow introduced at the ven-

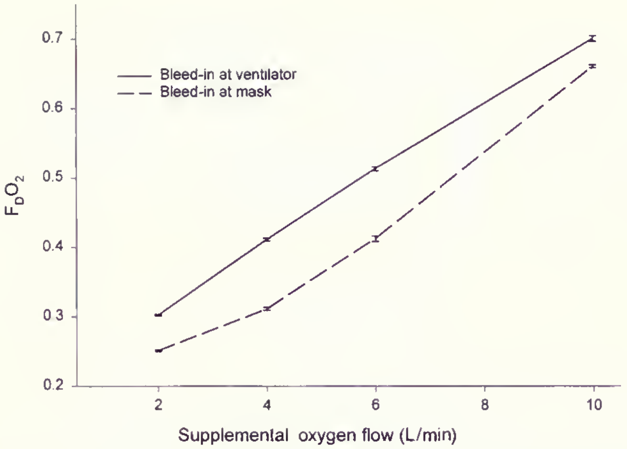

Fig. 3. The effect of changing the site of supplemental oxygen introduction on the mean fraction of delivered oxygen (F_{DO_2}) at selected supplemental oxygen flows, with an inspiratory time fraction (T_I) of 0.25. The error bars show the standard deviations.

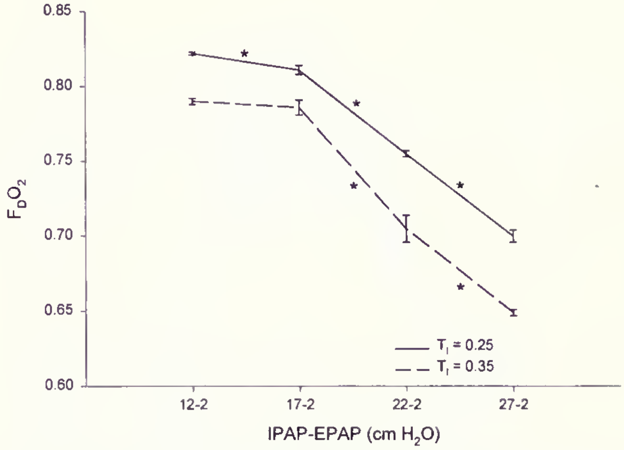

Fig. 4. Mean F_{DO_2} values at 4 expiratory positive airway pressure-inspiratory positive airway pressure (IPAP-EPAP) settings, with inspiratory time fractions (T_I) of 0.25 and 0.35, and with oxygen bleed-in proximal to the ventilator. $^*p \leq 0.003$. The error bars show the standard deviations.

tilator outflow connector (site A in Fig. 2). On average, each 1 L/min increase of oxygen flow between 1–10 L/min yielded approximately a 0.05–0.06 increase in the oxygen fraction delivered to the test lung for the given ventilator and test lung settings.

Effect of Supplemental Oxygen Introduction Site on the Fraction of Delivered Oxygen

Changing the site of oxygen introduction from the ventilator outlet (site A, see Fig. 2) to a point adjacent to the patient mask (site B) resulted in a 0.04–0.10 decrease in mean F_{DO_2} at all of the 4 selected supplemental oxygen flows from this range (see Fig. 3). A paired samples *t* test comparing the pooled values from the 4 oxygen insertion flows at the mask versus at the ventilator produced a $p < 0.001$, indicating that the F_{DO_2} values associated with oxygen introduction near the mask were significantly lower than those obtained from oxygen introduction near the ventilator outlet. Specifically, comparing F_{DO_2} values at each level of oxygen flow from both oxygen introduction sites using a one-way analysis of variance (ANOVA) with Tukey's post hoc test yielded p-values < 0.001 for each level of oxygen flow, indicating a uniform pattern of F_{DO_2} differences.

Effect of Manipulating Ventilator Variables on the Fraction of Delivered Oxygen

Using the same test setup with the oxygen flow set at 10 L/min and T_I at either 0.25 or 0.35, F_{DO_2} was measured at 4 different IPAP-EPAP combinations: (1) IPAP at 12 cm H_2O and EPAP at 2 cm H_2O; (2) IPAP at 17 cm H_2O and EPAP at 2 cm H_2O; (3) IPAP at 22 cm H_2O and EPAP at 2 cm H_2O; and (4) IPAP at 27 cm H_2O and EPAP at 2 cm H_2O (see Fig. 4). Pooling the mean F_{DO_2} values for the 4 IPAP-EPAP combinations within the 0.25 T_I and 0.35 T_I groups gave a $p < 0.001$ using a paired samples *t* test. A comparison of the F_{DO_2} values generated with each IPAP-EPAP combination within each of the T_I groups yielded p values $\leq$ 0.003, except for the 10 cm H_2O versus 15 cm H_2O IPAP-EPAP pressure gradient within the 0.35 T_I group ($p = 0.122$).

To determine whether a higher baseline pressure (EPAP) resulted in a different F_{DO_2} than a lower baseline while retaining the same pressure gradient between EPAP and IPAP, two IPAP-EPAP pressure gradients of 10 and 15 cm H_2O were generated with two sets of three different IPAP-EPAP combinations (Fig. 5). Within each pressure gradient (10 and 15 cm H_2O) the three IPAP-EPAP pairs, at 10 L/min O_2, were different, yielding p values < 0.001 using ANOVA with Tukey's test. In addition, supplemental oxygen at CPAP levels of 4 and 10 cm H_2O produced mean F_{DO_2} values of 0.71 and 0.48, respectively, at 10 L/min O_2, and 0.98 and 0.70 at 15 L/min O_2 at a spontaneous f of 10 and a V_T of 300 mL.

Discussion

We found that changing the point at which oxygen was added to the inspiratory circuit, altering the T_I by as little as 0.10, and changing the EPAP level while maintaining a constant pressure gradient, all significantly changed the F_{DO_2} under the given conditions. Introducing supplemental oxygen at the site most distant from the patient increased the mean F_{DO_2} 0.05–0.06 for each L/min increase in supplemental oxygen, and provided higher F_{DO_2} values than introducing oxygen near to the patient mask. This is log-

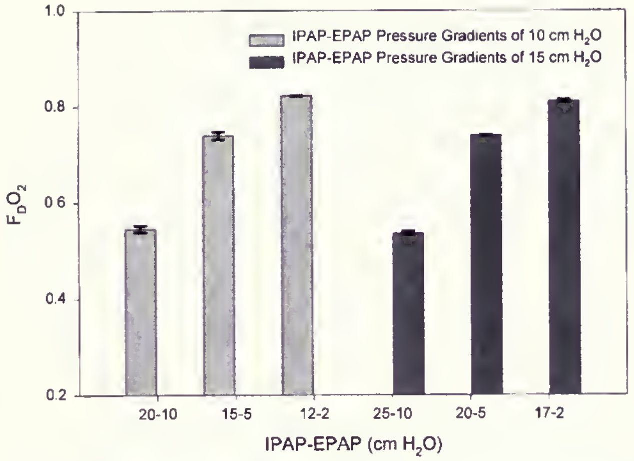

Fig. 5. The effect on F_{DO_2} of two expiratory positive airway pressure-inspiratory positive airway pressure (IPAP-EPAP) pressure gradient levels (10 cm H_2O and 15 cm H_2O) generated by different IPAP-EPAP combinations, with O_2 bleed-in proximal to the ventilator and an inspiratory time fraction (T_I) of 0.25. The error bars show the standard deviations.

ical, since the ventilator circuit would be expected to act as a reservoir that becomes more charged with oxygen the farther upstream supplemental oxygen is inserted. The latter finding was contrary to the findings of Padkin and Kinnear, who examined the effect of changing the oxygen bleed-in site during noninvasive ventilation, while sampling tracheal oxygen concentrations.[6] In that study, oxygen was introduced into the patient circuit either at the proximal ventilator site or into the patient mask at flows between 1 and 6 L/min using a Monnal D or DCC ventilator. No significant difference was observed between the two routes in the inspired oxygen concentration for any of the flows tested, and flow above 4 L/min had little additional effect on increasing the associated 0.44 inspired oxygen fraction. It is not clear whether these conflicting results are due to the different functional characteristics of the two types of noninvasive ventilators studied, or to some other variable. It is possible that flow dynamics within this particular brand of patient mask favored oxygen loss through the bleed-hole when oxygen was introduced proximal to the mask.

The Quantum PSV operator's manual warns not to introduce supplemental oxygen at the air intake of the ventilator, because the gas is not insulated from the electric motor of the flow generator (in NPPV devices the gas is typically not isolated from the flow generator) and oxygen levels above room air concentration would pose a fire hazard. Although adding oxygen next to the ventilator would provide a higher F_{DO_2}, it could also represent a fire hazard. Adding oxygen at some mid-point of the circuit might provide the optimal combination of F_{DO_2} and operational safety. Clinicians working with ventilators frequently modify and adapt equipment for better performance, but until further laboratory study shows otherwise, it is most prudent to insert supplemental oxygen near the patient mask.

In the present study, adding supplemental oxygen in the range of 1–10 L/min produced a predictable, linear response in F_{DO_2}. The use of only one respiratory system compliance and airways resistance setting is a limitation of this study. Oxygen flow of 10–15 L/min is sufficient to deliver a high F_{DO_2} (> 0.9) at V_T near the low end of the normal range in CPAP mode. Changing the T_I fraction by 0.10 significantly altered the F_{DO_2} at the pressure levels and oxygen flows tested. At a supplemental oxygen flow of 10 L/min, IPAP-EPAP pressure gradient increments as little as 5 cm H_2O caused significant changes in F_{DO_2}. This indicates that even subtle IPAP-EPAP pressure gradient changes can be a concern regarding a patient's oxygenation status.

Increasing the baseline pressure (EPAP) while maintaining a constant IPAP-EPAP pressure gradient significantly decreased the F_{DO_2}. Therefore, when arterial blood gases and oximetry values are evaluated after an EPAP change, the practitioner should take into consideration that two variables have changed, baseline pressure and F_{DO_2}. Further research is needed to determine the effects of ventilatory parameter changes on F_{DO_2} with other noninvasive ventilators. However, in the interim, our results suggest that, when using an NPPV functionally similar to the Quantum PSV, if ventilatory parameters are changed, F_{DO_2} should be reassessed and supplemental oxygen flow adjusted accordingly.

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Young Adult with Near-Fatal Pneumonia Caused by Adenovirus Serotype 7

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We report a case of severe adenoviral pneumonia in an immunocompetent male athlete. His presentation included dyspnea, cough, tachypnea, hypoxemia, rapidly progressive bilateral lung infiltrates, tracheobronchitis with bronchorrhea, left pleural effusion, and leukopenia with lymphocytosis. His course was complicated by thrombophlebitis despite prophylaxis, and by weight loss and alopecia. The etiology was adenovirus (serotype 7), which grew from bronchoalveolar lavage fluid and from pleural fluid. His oxygenation was much improved by bi-level positive airway pressure mask ventilation, which allowed him to avoid endotracheal intubation and mechanical ventilation during a three-week intensive care unit stay. Prior to discharge his pulmonary function test revealed severe restrictive lung disease. The total lung capacity was 58% of predicted and the diffusing capacity was 52% of predicted. His arterial blood gas showed hypoxemia at rest, with an arterial oxygen tension of 60 mm Hg on room air and arterial desaturation during exercise. All values returned to near-normal within six months and he was able to resume strenuous exercise without difficulties, and 22 months after this acute illness the patient was clinically well. [Respir Care 1999;44(5):524–527] *Key words: adenovirus serotype 7, viral pneumonia, acute respiratory failure, pulmonary function test, case report, mask ventilation.*

Introduction

Adenoviral pneumonia is a well-recognized entity in children and has been increasingly described in the adult population. Upper respiratory infections caused by adenovirus account for approximately 4–5% of all respiratory tract infections in children and in adults.[1] In adults, upper respiratory infection with adenovirus is typically seen in immunocompromised hosts[2] and has been described in epidemic outbreaks among military recruits.[3] However, documented cases of community-acquired adenoviral pneumonia in immunocompetent adults are uncommon.[4–7] These cases of adenoviral pneumonia in adults often require intubation and mechanical ventilation, which, in turn, are associated with complications and a prolonged hospital stay. Therefore, morbidity and mortality are increased in these patients. A recent review of the literature reported a 30% mortality rate in 10 adults with adenovirus pneumonia, which was twice as high as the rate previously reported in children.[3,4]

We report a case of severe adenoviral pneumonia in an immunocompetent male, complicated by severe lung injury, managed by bi-level positive airway pressure mask, and followed by essentially complete recovery at 6 months, sustained over 22 months of follow-up.

Case Summary

A 20-year-old white male college student-athlete was admitted to our hospital with a 2-week history of upper respiratory symptoms (Table 1). He had a past medical history significant only for *Legionella* pneumonia that resolved with antibiotic treatment approximately 3 years prior to this admission. He denied substance abuse and human immunodeficiency virus infection risk factors. He had no recent travel history or exposure to pets. No other students

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Table 1. Distribution of Symptoms, Signs, and Laboratory Results at Presentation in Adenoviral Pneumonia (n = 13)

Symptoms	Frequency, %	Signs or Abnormal Studies	Frequency, %
Fever*	86	Abnormal CXR*	100
Dyspnea*	71	Cough*	93
Myalgia	43	Fever*	86
Malaise*	36	Tachypnea*	71
Sore throat*	29	Hypoxia*	64
Headache	14	Normal leukocyte count	50
Weakness*	14	Leukopenia*	43
Dizziness*	14	Abnormal Chest Examination*	29
		Rhinorrhea	29
		Diarrhea	21
		Thrombocytopenia*	21

Only symptoms and signs in which 3 or more patients had on presentation are included.
*Observed in the patient described in the present report.

in his dormitory or his teammates were ill. His blood pressure was 130/50 mm Hg with a heart rate of 84 b/min while supine, and 86/48 mm Hg with a heart rate of 92 b/min while standing. He had a respiratory rate of 30 breaths/min and a temperature of 39 degrees Celsius. The rest of his physical examination was notable for a dry oropharynx and dry crackles heard over the left lung base. The skin, neck, cardiac, abdominal, extremity, and neurological examinations were unremarkable. Chest x-ray (Fig. 1a) revealed mild left retrocardiac infiltrate. His laboratory examination was significant for a white blood cell count of 3000 cells per mm^3, with 46% polymorphonuclear leukocytes, 16% bands, 25% lymphocytes, and a platelet count of 134,000 cells per mm^3. Human immunodeficiency virus 1 and 2 enzyme-linked immunosorbent, nuclear protein (p^{24}), complement, T and B cellular function assays performed 3 days after admission and repeated 3 months later were negative. Room air oxygen saturation (S_{pO_2}), electrolytes, renal function, and liver profile were normal.

Over the next three days, the patient's clinical symptoms worsened, with progressive breathlessness and severe hypoxemia requiring administering 40% oxygen by face mask to keep S_{pO_2} above 90%. Chest x-ray (Fig. 1b) and thoracic computed axial tomography scan (Fig. 2) revealed dense bilateral consolidations with pleural effusions. Bronchoscopy with bronchoalveolar lavage revealed diffuse tracheobronchitis with bronchorrhea. Pleural fluid examination revealed yellow turbid fluid with pH 7.39, lactic dehydrogenase 1916 U/mL (serum 611 U/mL), protein 3.6 gm/dL (serum 5.1 gm/dL), glucose 125 mg/dL, and 347 leukocytes with differential of 11% polymorphonuclear cells, 35% lymphocytes, and 38% macrophages. On day 6, the patient's oxygenation fell to S_{pO_2} less than 80% on 100% oxygen by face mask, and he was started on bi-level positive airway pressure mask with 100% oxygen. His antibiotics were changed to imipenem-cilastatin and doxycycline. On day 7, a chest tube was inserted for a recurrent left pleural effusion and a small pneumothorax. On day 11, his bronchoalveolar lavage fluid and pleural fluid cultures grew adenovirus. Further subtyping identified serologic subtype 7. We considered this diagnostic for adenoviral pneumonia, which had no specific treatment other than supportive care, and we stopped the antibacterial medications. The patient received a 3-week rapid taper course of oral prednisone, starting with 60 mg a day. His hospital course was complicated on day 15 by the development of multiple lower and upper extremity acute venous thrombi. Protein C, protein S, and antithrombin III levels were normal. Lupus anticoagulant and anticardiolipin antibodies were negative. He was started on heparin and Coumadin, without further recurrence of thromboses.

He was discharged in stable condition off oxygen therapy approximately 3.5 weeks after admission. Convalescent antibody titers to adenovirus on day 29 were greater than 1:64 (normal is less than 1:8). The illness resulted in a 9.1-kilogram weight loss, approximately 13% of his body weight, and 80% alopecia, both of which have resolved. At follow-up 6 months and 22 months after discharge, the patient had returned to his full activities, including crew and track. Key features of serial pulmonary function tests are summarized in Figure 3. Diffusing capacity increased from 68% of predicted initially to 88% of predicted at 6 months. In addition, the ratio of forced expiratory volume in 1 second to forced vital capacity decreased from the initial value of 92% to 75% at 6 months. Chest x-ray and high-resolution thoracic computed axial tomography scan at 6 months show almost complete resolution of the infiltrates.

Discussion

The family of adenoviruses, consisting of approximately 41 human serologic types, is responsible for a variety of illnesses, including pharyngitis, keratoconjunctivitis, enterocolitis, cystitis, and pneumonia—the latter often accompanied by acute respiratory distress syndrome.[1] Of these, respiratory infections tend to be the most common presentation, with adenovirus types 3, 4, 7, and 21 being the most common.[2–4,7]

Komshian et al[4] in 1987 reported a case of adenovirus pneumonia in a healthy adult. In their discussion they included a table of characteristic features of 10 nonepidemic adenovirus pneumonia in healthy adults. Since that report, only 3 additional cases of adenovirus pneumonia have been published,[6,7] and our current case adds to this rare patient population. Table 1 shows the most common presenting symptoms, signs, and laboratory study results in these 14 civilian patients with adenovirus pneumonia. The clinical manifestations of adenoviral pneumonia are

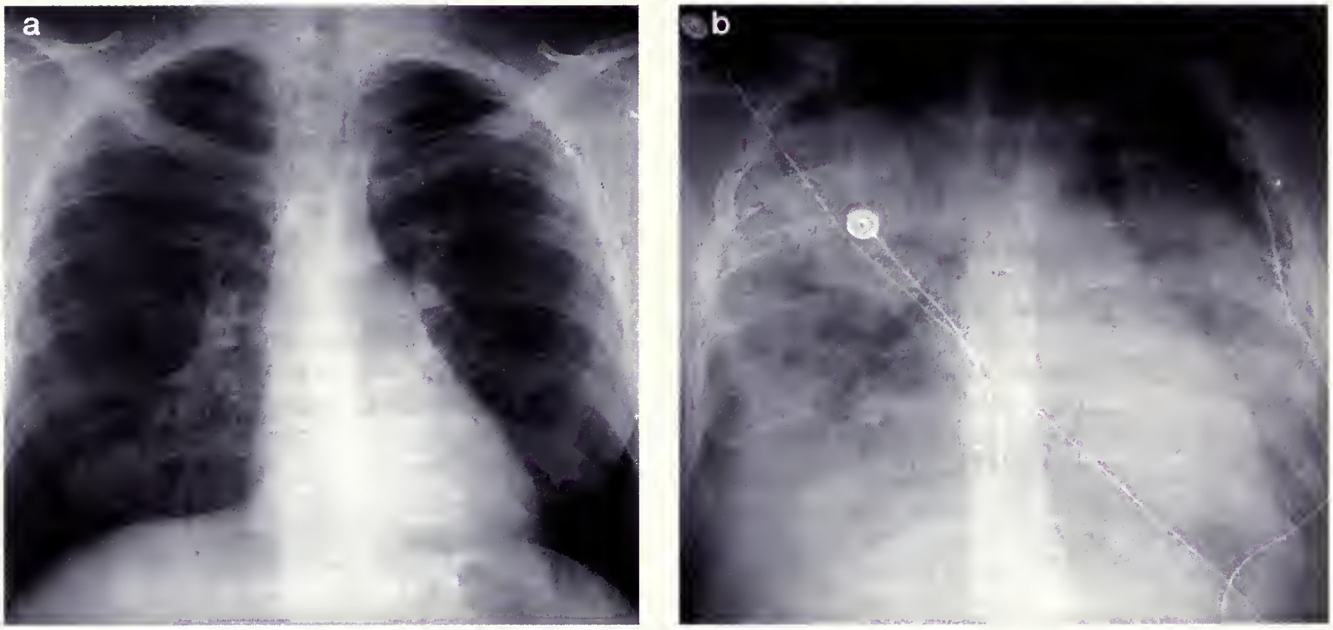

Fig. 1. Progression of adenovirus pneumonia on plain chest roentgenogram. 1a is the admission film, which shows a small retrocardiac infiltrate involving the left lower lobe. 1b shows a dramatic evolution (at day 8) into a dense, diffuse air space filling process.

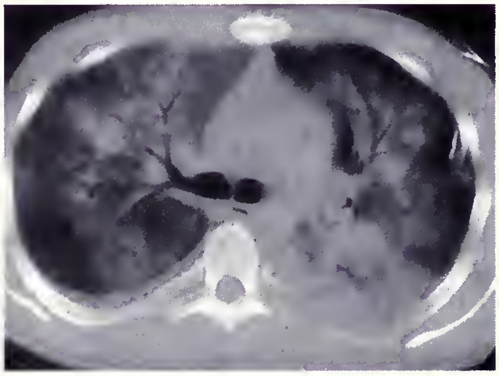

Fig. 2. Computed axial tomography of adenovirus pneumonia. The image shows the 10-mm cut at the level of the main carinae, performed on 5/10/97. The image clearly shows the dense diffuse air space filling lesions with air bronchograms.

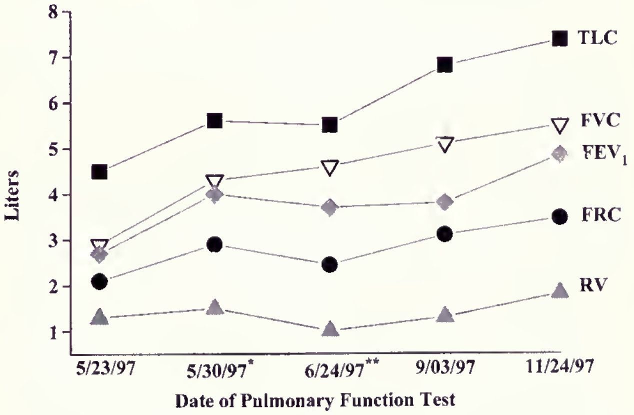

Fig. 3. Results of pulmonary function tests following near-fatal adenovirus pneumonia. TLC = total lung capacity; FVC = forced vital capacity; FEV_1 = forced expired volume in the first second; FRC = functional residual capacity; RV = residual volume. The * and ** indicate, respectively, the start and end of oral corticosteroid therapy. The effect of steroid therapy is difficult to interpret given the limited, uncontrolled nature of this administration.[10,11]

nonspecific and can easily be confused with other causes of pneumonia. The lack of specific symptoms and signs in patients with adenovirus pneumonia suggests that this important cause of severe and sometimes fatal pneumonia is often misdiagnosed or unrecognized. Although routine testing for adenovirus is not advocated, a low threshold is warranted in selected cases to decrease the number of invasive tests and unnecessary antibiotic exposure in these patients. Confirmation of the diagnosis usually depends on either isolation of the virus, as was done in this case, appropriate serologic antibody response, or subtyping.[7]

Unfortunately, no specific therapy is of proven benefit. Anecdotal reports of patients treated with ribavirin and immunoglobulin are inconclusive. Therapy is usually supportive, with better outcome reported in immunocompetent patients and in patients with localized pneumonia.[5,8,9] Corticosteroid therapy was instituted because of the possibility that the fibroproliferative phase of this patient's acute lung injury might resolve more quickly.[10,11]

Among childhood survivors of adenoviral pneumonia, bronchiolitis obliterans, bronchiectasis, reactive airways disease, and pulmonary fibrosis are reported as complications.[12,13] The time to recovery and complications of adenoviral pneumonia among adults are not well documented, though bronchiolitis obliterans has been seen, especially with types 3, 7, and 21.[13] Other reports suggest that partial to complete return to full activities may be seen with some pulmonary function impairment in adults with prior adenoviral pneumonia.[14,15]

There were several unique and interesting aspects to our case. First of all, our patient, a young healthy male, presented with acute symptoms of a respiratory infection that progressed to overwhelming pneumonia with bilateral consolidations on chest x-ray, and severe hypoxemia over 2 days. He responded to bi-level positive airway pressure and was managed with noninvasive mask ventilation, thus avoiding intubation and invasive ventilation and its attendant complications. Continuous positive airway pressure has been used in the management of patients with hypoxemia due to increased lung water secondary to either increased capillary permeability or increased hydrostatic pressure in order to decrease pulmonary shunt. Several reports suggest that patients with viral pneumonia respond to continuous positive airway pressure.[2,16] At the height of our patient's illness, elective intubation was considered appropriate on several occasions, but each time the dyspnea and tachypnea were sufficiently relieved by adjustments to the positive inspiratory pressure of bi-level positive airway pressure, while S_{pO_2} was increased to above 90% by the continuous positive airway pressure component. We found it necessary to operate the bi-level positive airway pressure from a ventilator source to ensure effective delivery of positive inspiratory pressure and the intended fraction of inspired oxygen.

Our patient developed multiple venous thromboses of both upper and lower extremities, without any laboratory evidence of a defined coagulation disorder. Adenovirus infection[4] and various other infections[17] have been associated with vascular thromboses involving vessels of all sizes. Adenovirus infection may have predisposed our patient to developing thromboses. However, the cause of this association is unclear. Similarly, we found no reported association between adenoviral infection and alopecia. We attributed the extensive weight loss to the debilitating systemic illness in this muscular patient.

Our patient's severe adenoviral pneumonia and the prior *Legionella* pneumonia raised concern about his immunocompetence, but screening evaluations for obvious immune defects remained negative. Human immunodeficiency virus 1 and 2 enzyme-linked immunosorbent, nuclear protein (p^{24}), complement, and T and B cellular function assays performed 3 days after admission and repeated 3 months later were negative except for a low acute immunoglobulin G level. The patient has returned to complete cardiopulmonary fitness and experienced no serious illness in the 22 months following discharge. His cardiopulmonary exercise test demonstrated an oxygen consumption of 120% of predicted. Pulmonary function testing initially revealed restrictive lung disease that improved over the ensuing months (see Fig. 3), with the corresponding radiographic improvement confirmed by high resolution computed axial tomography scan (see Fig. 2). This improvement is in contrast to previous reports of long-term sequelae that have been described in children with adenoviral pneumonia[13].

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Implementing a Respiratory Care Protocol Service: Steps and Impediments

Douglas Orens MBA RRT and James K Stoller MD

Introduction

Implementing a respiratory care protocol program involves introducing a new service to physicians, nurses, administrators, and other health care providers. The success of the program will depend on careful implementation to launch effectively and to establish a positive first impression.

This paper considers steps and impediments to implementing a respiratory care protocol service. The process is described (Table 1) in the temporal sequence of: (1) aspects before implementation and (2) the implementation phase.

Before Implementation

Overview

Development of a respiratory care protocol service begins months before the implementation date.[1] This pre-implementation or planning phase starts with organizing a team to plan the protocol program and to address all operational aspects of providing a respiratory care protocol service. An initial audit is a key first step to ascertain the frequency of misallocation of respiratory care services, a problem for which a respiratory care protocol service represents a potential solution. The pre-implementation phase also involves identifying potential impediments to a respiratory care protocol service and creating a plan to constructively address each identified potential impediment. Finally, decisions regarding the type of protocol service—whether a single respiratory care protocol or a full spectrum of respiratory care services—are also required during the pre-implementation phase.

Planning Team

The planning team is an essential component of the development and pre-implementation phase of a protocol service. The team should reflect broad membership within the department of respiratory care and should include the medical director, manager/director, supervisors, the education coordinator, clinical specialists, and selected staff therapists. Activities of the team will include: developing the initial protocol program, developing an operational plan for phase-in, identifying barriers to success and strategies to address these potential barriers, developing feedback and reporting mechanisms to identify problems, and proposing strategies to make adjustments to the program once problems are identified.

Necessity of a Baseline Audit of Respiratory Care Services

In order to justify the departure from traditional physician-directed respiratory care that a respiratory care protocol service entails, assessing whether misallocation of respiratory care is occurring is a crucial pre-implementation step. To the extent that respiratory care protocol programs have been shown to lessen misallocation, identifying misallocation in an audit can provide strong justification for implementing a respiratory care protocol service.[2,3] On the other hand, if misallocation either is not occurring or is uncommon, then the impetus for a respiratory care protocol service is less strong.

Planning an allocation audit requires specific consideration by the planning team of types of services to be examined, the hospital areas in which to perform the audit, and which costs and patient outcomes to consider.

Determining the Type of Protocol

Once the need for a protocol service has been demonstrated by an audit, protocol development is the next step.

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Table 1. Steps in Implementing a Respiratory Care Protocol Service

Phase	Measure
Before Implementation	· Assemble the planning team · Perform a pre-implementation audit of respiratory service to study whether misallocation of respiratory care is occurring · Identify sources of resistance to implementation · Assure adequate training of respiratory care staff
During Implementation	· Actively seek feedback about whether the program is working. Seek feedback from respiratory care practitioners, physicians, nurses, administrators, and any other involved parties · Make tactical decisions regarding the type of protocol program and the hospital setting in which to initiate the program · Formally assess the program and present results to institutional decision-makers

Drafting the actual protocols requires an understanding of the different types of protocols available, whether disease-based, treatment-based, or sign/symptom-based.[4] Developing a disease-based protocol, such as an asthma protocol, requires state-of-the-art understanding of the disease process and available therapies, as well as operationalizing a treatment plan. Our experience suggests that protocol programs using disease-based protocols require more initial development and can be somewhat confusing to assessors, especially when patients have multiple diseases.

As an alternative, treatment-based protocols can be developed for specific modalities of respiratory care. Use of treatment-based protocols allows the protocol program to treat many types of patients by determining whether there is an indication for the specific respiratory care modality.

As a third option, sign/symptom-based protocols (such as those used in the Respiratory Care Consult Service at The Cleveland Clinic Foundation) base the respiratory care plan on the patient's specific respiratory signs and symptoms, independent of the underlying disease. For example, using a sign/symptom-based strategy, patients who are wheezing, whether caused by asthma, chronic obstructive pulmonary disease (COPD), or congestive heart failure, would be evaluated under a "wheezing protocol." Well-designed protocols allow for differentiation of different etiologies that impact treatment. Finally, protocol programs may use a combination of different types of protocols.

Another decision about the type of protocol regards the format. A spectrum of options exist, from algorithms (which present branched logic diagrams for dichotomous decisions) to more narrative guidelines. Combinations of narrative guidelines and flow diagrams are commonly used.

Identifying Potential Barriers

Another important aspect of planning a protocol service is identifying potential impediments to successful implementation.[1] In this regard, four major groups of shareholders within the hospital environment can impact successful implementation.

Members of the Respiratory Care Department. Members of the respiratory care department can pose barriers. For example, without the support of the medical director of respiratory care, the protocol program can flounder. Active participation of the medical director in protocol development can help assure him/her that appropriate respiratory care will be delivered, and thus garner support. The medical director's potential concerns about the competence of respiratory care evaluators in a protocol program can be assuaged by involving the most capable respiratory care practitioners.

A respiratory care manager/director can be a barrier to successful protocol implementation if he/she is comfortable with the status quo. Lack of personal confidence in developing a new program, concerns about limited resources, or a lack of support from the administration or medical director can constrain the respiratory care manager. In the context that the respiratory care department may be viewed as a "cost center" by the hospital administration, the respiratory care manager must view the respiratory care protocol service as a means to improve allocation and to maintain quality care while avoiding unnecessary costs due to overordering.

Respiratory care supervisors can hamper the protocol service if they are uncomfortable with the concept of protocols or feel that adding a new service creates additional work for an already overburdened staff. Our experience suggests that although work loads may rise initially while the program is being planned and launched, long-term efficiencies of lessening misallocation offset these initial increases in work.

Respiratory care educators may lack confidence in their ability to help develop a protocol program and/or train staff regarding assessment and protocol implementation. An education coordinator may lack sufficient resources or support to direct training or program development. Both of the latter issues require the planning team's attention. Involvement by respiratory care educators in pre-implementation planning will help identify the necessary support and resources for successful implementation.

Finally, staff respiratory therapists can present barriers to success. Respiratory care staff may oppose change or lack motivation to leave the comforts of the traditional

Table 2. Sources of Resistance to Implementing a Respiratory Care Protocol Service

Source	Possible Concern
Medical Director of Respiratory Care	· Possible lack of confidence in respiratory care management and/or staff · Reluctance to take on the responsibilities of helping to plan and implement a protocol program
Respiratory Care Manager/Director	· Reluctance to leave the comforts of the status quo, concerns about ample resources or support to launch a program
Respiratory Care Supervisor	· Concern over increased work load · Discomfort with protocol concept
Respiratory Care Staff	· Reluctance to leave comforts of "task-driven" respiratory care · Uncertainty about assessment skills
Hospital Administrators	· Concern that respiratory care protocols will increase costs and/or worsen outcomes
Physicians	· Lack of confidence in assessment skills of respiratory care practitioners · Concern over losing clinical autonomy · Concern that respiratory care protocols will lessen the number of pulmonary consultations · Concern that a respiratory protocol program will detract from trainees' learning about respiratory care
Nurses	· Concern about the conflicts with respiratory care practitioners, eg, in patient-focused care models

model of "task-driven" respiratory care. Therapists may not wish to take on the additional job responsibilities of a protocol program or may lack the skills or confidence necessary to perform assessments and to make clinical decisions, even in the context of a structured protocol program. To address these staff barriers, the planning team must emphasize the important goals of improving allocation of respiratory care services while citing the available evidence that respiratory care protocol programs enhance professionalism and improve respiratory care practitioner morale. Overall, the planning team should emphasize the fact that a respiratory care protocol program can address misallocation, which can be a source of poor morale.

Hospital Administration. The hospital administration (Table 2) can be another source of resistance to implementing a respiratory care protocol service. Recent changes in health care reimbursement have focused significant attention on cost containment. Indeed, many cost-cutting strategies have been adopted in recent years, such as reduction in personnel, decentralization of respiratory care departments, and work redesign. At first view, a protocol program may appear costly or inefficient to hospital administrators. To address these concerns, the planning team must share available data regarding the efficacy of respiratory protocol programs and their favorable impact on cost, largely related to eliminating inappropriate respiratory care services.[5,6]

Physicians. Resistance by physicians to implementing a respiratory care protocol service can be based on several concerns: (1) perception that a respiratory care protocol service will erode clinical autonomy, (2) concern that a respiratory care protocol service will unfavorably affect the volume of pulmonary consultations, (3) concern in training institutions that use of a respiratory care protocol service will hinder house officers' abilities to learn respiratory care prescribing, and (4) concern that respiratory care protocols will not reflect physicians' preference regarding clinical management.

In the context of these concerns, key aspects of gathering physician support are to: (1) engage physicians in the process of developing the protocols so that their clinical needs are reflected in the protocols, (2) undertake studies of the volume of pulmonary consultations and share the evidence that use of respiratory care protocol programs has not caused a decrease in pulmonary consultations, at least in observations at a closed-staff tertiary care institution, (3) ascertain clinicians' preferences for respiratory care so as to develop acceptable, customized protocols where needed, and (4) evaluate the impact of a respiratory care protocol service on house staff education. Regarding house staff education, preliminary studies suggest that most house officers perceive a respiratory care protocol service as enhancing their ability to prescribe respiratory care, with only a minority suggesting otherwise.[7]

Finally, organizing forums to discuss available literature regarding respiratory care protocols with physicians (eg, journal clubs and medical grand rounds) may be a useful strategy to review the rationale for a protocol service.

Nursing. Although the nursing staff can also be a possible source of resistance to implementing respiratory care protocols, they can also be an important ally. Nursing staff may have concerns about role conflicts (eg, in patient-focused care models). Concerns about respiratory care protocols can cause nursing to defer providing much-needed clinical feedback. On the other hand, by cultivating a collaborative relationship with nursing, we have observed that nurses are often important "ambassadors" for respiratory care protocols (eg, by inviting physicians to use the respiratory care protocol service). Of course, nurses' clinical assessments also provide additional feedback regarding an individual patient's clinical responses to respiratory therapies.

During Implementation

Having planned the protocol program and having addressed impediments to implementation, tactical decisions regarding implementation are needed. It is necessary to decide whether to roll out a single protocol (eg, for an individual respiratory care modality) or to create a complete protocol program (ie, with many different protocols). Both of these strategies have advantages and disadvantages. A pilot program with a single protocol is easier to administer and may be preferable in settings where there is initial resistance to a protocol program. However, building a total respiratory care protocol service by adding one protocol at a time requires serially adding protocols and repeated modifications of the emerging protocol service. Conversely, implementing the full-program service initially on a limited number of hospital wards affords the opportunity to evaluate operational aspects of the whole program and to make appropriate adjustments. But this full-program implementation approach suffers the disadvantage of greater complexity for staff therapists and managers.

A related tactical decision is whether to initiate the pilot program in a restricted setting (ie, one or two hospital wards only) or to begin hospital-wide. On the basis of our experience, we favor a limited roll-out in order to allow time to evaluate problems, to make appropriate adjustments, and to orient respiratory care staff and others. However, the limited roll-out strategy precludes involving the entire respiratory care staff at the program outset, and, with this strategy, broader implementation will require a series of staff orientations. In implementing the Respiratory Therapy Consult Service at The Cleveland Clinic Foundation, we began with a pilot study of a full-service program on two wards (one medical and one surgical). Having studied the roll-out program, we were able to identify and address operational shortcomings and make appropriate adjustments.[8] Experience from this pilot study lead to institutional approval to expand the protocol program hospital-wide.

Another important aspect of implementing a protocol service is to develop an ongoing evaluation process. Feedback should be widely sought, from staff therapists, supervisors, nurses, the medical director and other physician "consumers," and from the hospital administration. For the program's architects, acknowledging and rectifying flaws and oversights in a nondefensive, self-critical spirit is essential to constructively optimizing the protocol program. As an example of lessons learned from our pilot experience at The Cleveland Clinic, we recognized the importance of "customizing" some protocols to enhance specific physician acceptance. Specifically, to avoid the practice of ordering respiratory care services with high frequency (eg, every two hours) in order ensure at least four-times-daily visits, we developed protocols resembling "critical paths" with day-by-day targets and treatments. In such "critical path" protocols, mandatory respiratory care services are specified for the first hospital or postoperative day. On day 2, continuation of these services depends on assessments performed by respiratory care practitioners using relevant protocols. This strategy of identifying concerns and making adjustments to address the concerns during protocol implementation has been a critical element in the success of our program.

Summary

In summary, successfully implementing a respiratory care protocol program requires attention to important details and tactical decision-making. Important steps include: assessing whether misallocation of respiratory care services occurs; identifying obstacles to implementation and addressing these obstacles; deciding what type of program is needed; deciding where in the hospital to launch the program; and adopting a self-critical posture in which candid feedback is sought and utilized. A commitment to seeking flexible, creative, and interactive approaches with other health care providers is strongly recommended.

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Practical Aspects of a Respiratory Care Protocol Service: Staffing and Training

Irene Thaggard RRT and James K Stoller MD

Introduction

Training and staffing are essential elements of a successful respiratory care protocol service,[1,2] but have received little attention in the literature. This article addresses common, practical issues regarding training and staffing. These issues include: Who will administer the respiratory care protocols? What is the spectrum of roles for respiratory care practitioners? How will training be undertaken?

Training for Respiratory Care Protocols

Training should begin early in the implementation process and should include the following:

1. Review by trainees of the rationale for respiratory care protocols, including reading key studies from the literature.
2. Review of operational aspects of respiratory care protocols,[2,3] including patient assessment, assignment of risk scores, protocol application, and forms completion.
3. Introduction to monitoring procedures used in the consult service (eg, case study exercises and audit programs).

Training sessions may include journal clubs to review the literature and in-services regarding specific procedures used in the protocol service. Such training sessions should be scheduled to accommodate all shifts so as to permit broad exposure for respiratory care staff. Training materials must also be provided, and should include copies of abstracts and papers, the algorithms or care plans used, and the American Association for Respiratory Care Clinical Practice Guidelines.

At the onset of training, it is important to identify a core group of therapists who will administer the training program. This group should include the department head, the medical director, key staff physicians, supervisors, and motivated members of the respiratory care (and, possibly, nursing) staff. Important attributes of the training staff are enthusiasm, visibility, and ability to motivate and to address concerns regarding the respiratory care protocol program. Early tasks of the training group include scheduling training sessions and setting specific goals and time frames for each member of the training team. Good communication among the training staff and between trainers and trainees is also essential.

In addition to training the respiratory care staff, it will be helpful to orient nursing staff and physicians to the new service. Training of nursing personnel should consist of in-services to individual nursing units, with instructions about whom to call for patient consult evaluations, which forms will be used, an overview of the protocols, and how to access the respiratory care plan in the medical record.

Regarding orienting physicians, the medical director will play a key role in introducing the service to physician colleagues. Other important strategies are distributing the algorithms to the entire medical staff and house staff, as well as delivering lectures to the medical staff regarding outcomes associated with the respiratory care consult service.

A very important aspect of training is to establish selection criteria for consult evaluators. Ideally, evaluators should be registry certified (or at least eligible), have strong skills in patient assessment, problem solving, and communication, and be charismatic. Consult evaluators need to have well-developed respiratory care skills, but also should be ambassadors for the program and educators to other health care providers regarding the delivery of appropriate respiratory care. Although a large volume of consults may permit assigning therapists exclusively to the evaluator role on some shifts in large institutions, small institutions may need therapists to serve both as evaluators and treating therapists on the same shift. In this circumstance, these therapists may be responsible for the evaluations ordered in his/her assigned hospital ward. Clearly, this requires training all therapists to serve in the evaluator role.

Instructional materials can greatly facilitate training. For example, it can be helpful to distribute consult service handbooks that present the operational features, forms, and algorithms used in the consult service.

To enhance training in applying the algorithms and to ensure standardized application, our institution has devel-

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oped case studies that are periodically distributed to all staff therapists. The case studies are a series of patient vignettes for which each therapist is asked to apply the algorithms to develop a respiratory care plan. This constitutes a type of open book examination, for which correct answers are developed beforehand by a group of senior therapists. The submitted care plans are then graded against the answer keys and feedback is provided to the therapists. In this way, feedback on care plan development is provided to all staff members. These case studies can also help identify which therapists have the strongest assessment skills, which may qualify them to be evaluators.

In training therapists for the consult service, methods of data gathering should be taught so that each therapist knows *where* to obtain the necessary data, *what* data are important to glean from the patient's chart, *why* it is important to obtain the data, and *how* to gather the information. At The Cleveland Clinic Foundation we use a triage form[3] to provide a structured method of gathering data (see Figure 1, which shows the triage form, in the article by Kester and Stoller in this issue of RESPIRATORY CARE).[4] The triage score, which is derived from the data elements on this form, can help assess respiratory care needs and determine the frequency and intensity of respiratory care provided.

Clearly, to the extent that successful protocol implementation requires competent patient assessment, training for protocol programs should include a review of patient assessment skills, including history-taking, focused physical examination, understanding of pulmonary function test results, and understanding of the implications of chest imaging studies. If patient assessment includes performing pulmonary function tests (eg, spirometry), competent technique must be assured.

Overall, training is a pivotal aspect of a respiratory care protocol program and requires a carefully structured approach. Attention to the elements discussed above will serve to enhance training.

Staffing for a Respiratory Care Protocol Service

Staffing a respiratory care protocol service is another critical element of successful implementation. Once personnel are fully trained, staffing issues and challenges include: (1) assigning appropriate personnel to roles as evaluators and treating therapists, (2) assigning appropriate numbers of individuals to these roles to accommodate the demands on each shift, and (3) transitioning from providing respiratory care by a traditional physician-directed strategy to the protocol-directed respiratory care service. In this context, specific staffing issues include:

1. Choosing a staffing strategy. Will there be a group of designated evaluators who primarily perform evaluations and administer those therapies deemed urgently needed by the patients being evaluated, or will there be therapists both performing evaluations and administering therapies?
2. Estimating the number of evaluations expected each day (eg, weekday vs weekend) and by shift.
3. Assessing the amount of time required for each evaluation, so that an appropriate number of evaluations can be assigned per shift.
4. Structuring the day to allow time for consult rounds, during which therapists meet once per shift to discuss patients and to justify the current respiratory care plans.

Each of these issues is discussed below. Specific responses will determine key structural features of the respiratory consult program.

Table 1. Mean Number of Daily Respiratory Case Consults by Shift in 1997

	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Day Shift	5.26	6.96	7.38	7.53	7.41	7.40	6.59
Evening Shift	9.63	10.50	10.50	10.25	9.90	6.15	6.21
Night Shift	4.00	3.67	3.92	3.50	3.44	2.61	2.00

First, the choice of staffing strategy will reflect the type of protocol program, the institutional and departmental size, and the capabilities of the respiratory care staff. In a large institution (such as The Cleveland Clinic Foundation) with a respiratory protocol service that administers most respiratory therapies under protocol guidance, it can be appropriate to designate evaluators to see all new patients, perform assessments, and generate respiratory care plans that are communicated to the therapists who administer the therapies. In smaller institutions, where fewer therapists are available or where the number of new evaluations does not warrant assigning therapists for evaluations only, it may be preferable for the same therapists to both perform evaluations and administer therapies.

Knowledge of the patterns of respiratory care demands on a shift-by-shift basis is very important for staffing. For example, at The Cleveland Clinic Foundation, 80–100 patients per day receive protocol-based respiratory care, with approximately 10 patients undergoing new consult evaluations each shift. The most new consults are required on the evening shift (Table 1), when surgical patients return to the regular nursing floors from the operating room or recovery areas. As a result, we currently staff one consult evaluator on the day shift (7:00 AM to 3:30 PM) with an additional evaluator starting at 1:00 PM. The evening shift then has two evaluators, with another evaluator scheduled to start at 9:00 PM. Thus, by the beginning of the night shift (11:00 PM), most new consult patients have been evaluated. No evaluator is assigned to the night shift, but urgent consults are performed by the shift supervisor or other available trained evaluators. Although staffing is scheduled to accommodate the usual patterns observed, therapists' responsibilities are flexibly allocated. During shifts when the volume of new consults is low, evaluators take on reassessments of patients already receiving consult-directed care, assist with administering therapies, and conduct consult rounds.

Optimal staffing also requires knowledge of both the pattern of consult requirements (ie, by shift over the day and over the week) and the time required for each consult. Clearly, the time requirements vary in relation to the complexity of the patient's condition and the evaluator's experience. Our experience suggests that a veteran evaluator requires 20–30 minutes per patient to develop a respiratory care plan. Of course, managers should assess the per-consult time requirement in their own institutions to optimize staffing patterns.

Consult rounds are an integral part of a consult service. As a patient's clinical status changes, so do his or her respiratory care needs. Thus, appropriate allocation of respiratory care requires regular reassessment. Strategies for reassessment are to perform formal re-evaluations periodically and also to reevaluate patient needs and status on a shift-by-shift basis. Consult rounds provide the daily forum for altering patients' respiratory care plans based on therapists' presenting and defending respiratory care plan suggestions in the presence of colleagues and evaluators.

Because consult rounds are necessary for the daily conduct of consult service-directed respiratory care, attendance by all therapists should be mandatory. At the same time, accommodation to therapists' busy schedules must be made at times, possibly by telephone conversations between evaluators and therapists or, when face-to-face meetings are needed, by providing incentives for therapists' attendance at consult rounds.

Summary

In summary, training and staffing for a respiratory care protocol service pose some challenges for respiratory care managers, especially during the transition from traditional physician-directed respiratory care to a protocol-based program. Based on our experience with a respiratory care protocol service at The Cleveland Clinic Foundation, we believe that attention to the issues discussed above should help to organize the training and staffing of a respiratory care protocol service.

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Books, Films, Tapes, & Software

Listing and Reviews of Books and Other Media. Note to publishers: Send review copies of books, films, tapes, and software to RESPIRATORY CARE, 600 Ninth Avenue, Suite 702, Seattle WA 98104.

Acute Respiratory Distress Syndrome: Cellular and Molecular Mechanisms and Clinical Management, Sadis Matalon and Jacob Iasha Sznajder, Editors. (NATO: Advanced Science Institute Series, Vol 297) Hardcover, illustrated, 432 pages. New York: Plenum Press; 1998. $129.50.

The contents of this book are the proceedings of a NATO Advanced Science Institute on acute respiratory distress syndrome (ARDS), held in Corfu, Greece in June 1997. The contents of the book can be separated into several parts. The first part describes the mechanisms responsible for the pathogenesis of ARDS, such as: the early inflammatory response; the importance of oxidants; the role of lung lymphatics, Na^+, and water transport to clear lung edema during hypoxic conditions or in fetal life; mechanisms altering gene expression; pulmonary microvascular occlusion; and the important role of matrix macromolecules.

The second part is devoted to mechanical ventilation. The reader can find aspects of respiratory system mechanics, recommendations about how to set the ventilator to minimize barotrauma or volutrauma, and the contribution of the ventilator versus other stimuli in the progression of lung injury in ARDS or as a cause of ARDS in patients with noninjured lungs.

The third part is devoted to the management of ARDS and to the adjuncts to mechanical ventilation such as positive end-expiratory pressure, tracheal gas insufflation, partial liquid ventilation with perfluorocarbons, surfactant replacement, and inhaled pulmonary vasodilators. This book is addressed to respiratory therapists and physicians, especially intensivists, pulmonologists, and anesthesiologists who take care of patients with acute lung injury receiving mechanical ventilation. The contents of the first part are also useful for those professionals who have an interest in pathophysiology and basic research on acute lung injury.

The authorship of the book is diverse and adequate since recognized experts are the contributors. Some parts of the book are very extensive, like the chapters dealing with the pathogenesis of ARDS, but coverage of other topics—such as epidemiology, complete description of respiratory system mechanics, or specific currently-used therapies to treat ARDS (corticosteroids) or therapies to improve ventilation distribution (prone position)—is lacking. The organization of the book is less than ideal; chapters are not numbered and the distribution is rather heterogeneous. Moreover, references are scarce in some chapters and the text of one chapter is not supported with bibliography.

The book is readable and quite clear in aspects of basic science that could not be reviewed in a short period of time. Some short chapters are presented without illustrations but in general are clear and appropriate. The chapters have multiple authors and are well written, though the style is quite liberal (different type fonts are used). I would highlight some of them that are extremely clear or very well referenced, with excellent line drawings: alveolar and epithelial fluid transport (Matthay MA et al), surfactant replacement (Spragg RG et al), strategies to speed lung healing (Ingbar DH, et al), use of liquid ventilation (Verbrugge SJC, et al) and, reactive oxygen and nitrogen species and ARDS (van der Vliet A, et al). In summary, this is a book to be read by those who care for patients with ARDS. It is also of use for all those conducting research in the field of the pathogenesis and treatment of ARDS.

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Mosby's CPG Mentor: Patient Cases in Respiratory Care. Unit Three: Aerosol Therapy. 3 floppy disks. Lonny J Ashworth MEd RRT and Stephen Howe MA MS, developers; Jeff Anderson MA RRT (author of Unit 3) and Robert D Hase MS RRT, series authors. St. Louis, MO: Mosby Inc: 1998. $175.00.

System Requirements: PC with Microsoft Windows 3.1, Windows 95, or Windows NT operating environment, minimum 486 or Pentium processor, 8 MB RAM and 5 MB free hard disk space per unit, 3.5″ floppy drive, and 640 x 480 monitor with 256 colors or better.

Mosby's CPG Mentor: Patient Cases in Respiratory Care is an 8-unit set that is designed to teach respiratory therapists and students to evaluate patients and modify therapy based on the standards of the American Association for Respiratory Care's published Clinical Practice Guidelines(CPGs). The comments that follow are specific to Unit 3 only, and not to the complete set, which includes units on hyperinflation therapy, oxygen therapy, bronchial hygiene, invasive and noninvasive blood gas sampling and analysis, mechanical ventilation, resuscitation, and spirometry and lung volume measurement.* The general nature of the title of Unit 3 implies that most or all aspects of aerosol therapy will be addressed. This notion was supported by the inclusion of 6 of the published CPGs, ranging from selection of an aerosol-producing device to bland aerosol administration. However, the buyer should carefully read the publisher's enclosed description of the Unit 3 content and realize that the practice and exam cases are limited to aerosolized bronchodilator administration. This is not apparent in what is printed on the packaging. Perhaps the unit should be renamed "Aerosolized Bronchodilator Therapy" to more specifically reflect that focus.

The software is provided on 3 floppy disks, which installed quickly on a 166 Mhz Pentium based PC running Windows NT Workstation 4.0. A complete, easy-to-read black and white user's guide is provided, and the instructions for the administrator-access function are printed on a separate card. The opening screen provides a visually pleasing format with the various components displayed across the top tool bar. Selecting "Mentor" produces a tutorial and reference group of large icons from which the user may select a complete copy of any of the 6 CPGs that are pertinent to aerosol therapy, plus a narrative explanation of how the CPGs interrelate with one another. There is also an icon for an aerosolized bronchodilator therapist-driven protocol (TDP) that forms the basis for patient assessment and decision-making throughout the package. By clicking on the TDP icon in this section, the user may display or print a decision-making algorithm. Studying the material in this section is key to successfully negotiating the patient practice cases and exam.

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*Editor's Note: The publisher would provide only one of the 8 units for review. Thus, we are unable to comment on the contents or quality of the other units.

There are 4 selections under the patient practice heading. The first is a very thorough qualitative review of patient assessment that leads the user through all of the assessment choices that are appropriate for aerosolized bronchodilator therapy. The other 3 are patient case simulations for practice.

The first case covers the emergency management of an exacerbation of asthma and instruction of a young adult female. It includes oxygen therapy, monitoring, and full bedside assessment. The program requires the user to remain with the patient until 75% improvement is achieved (I was scolded for reporting to the emergency room physician too soon).

The second case involves a mechanically ventilated patient with chronic obstructive pulmonary disease. The user is challenged to optimize lung compliance, airway resistance, and auto-PEEP (unintended positive end-expiratory pressure) through the choice of various medication delivery devices, dosing strategies, placements in the circuit, and breath delivery contours. This is all accomplished through the selection and guidance of gathered assessment information.

The third case presents emergency management of a 4-year-old asthmatic patient who has failed to respond to conventional aerosol medication delivery. The simulation leads the user to set up a continuous large volume medication nebulizer. It requires the calculation of dose/h and duration using patient weight, nebulizer output, drug concentration, F_{IO_2}, total delivery time, and gas flow.

The practice section includes everything that is essential to learn to manage bronchodilator therapy. The program does a nice job of requiring the user to select and integrate assessment data to optimize the therapy. With each selection there is a feedback paragraph that indicates agreement or disagreement, explaining why the user was correct or incorrect in making the selection.

The package includes a well designed exam that is accessible via administrative password. This allows a student to use the practice and mentor features without having access to the exam sequence. When testing is desired, the administrator can enable the exam and automatically disable the mentor and practice features. This flexibility allows an educator to use the same software both to teach and subsequently to test a candidate. The exam feature automatically displays the examinee's scores at the conclusion of the exam and logs them for retrieval by the administrator.

The exam consists of 2 cases in which the user must assess and provide aerosol medication delivery. The exams and practice cases embrace the concepts of higher-level dosing guided by assessment (up to 8 puffs of albuterol) and seem to favor the use of metered-dose inhalers or large volume continuous-use medication nebulizers.

The CPG Mentor software thoroughly accomplishes its intent—preparing the user to implement a TDP. The format is attractive, with no detected typographical errors. The sections are well conceived and the functional mechanics are intuitive to one who is acquainted with Windows operations. If the other 7 units are similar to Unit 3, the package will be very helpful to a department that is gearing up to institute a consult-based practice. It will also be attractive to faculty of advanced practitioner-level educational programs that are modifying their curricula to meet the demands of the revised National Board of Respiratory Care exam matrix. If the title is left unchanged, it would be appropriate to include a protocol and practice and exam cases on bland aerosol administration.

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Respiratory Care Pearls. Frank A Mazzagatti MSA RRT, Leon C Lebowitz RRT and Neil W Schluger MD. (The Pearls Series, Steven A Sahn MD and John E Heffner MD, Editors) Softcover, illustrated, 200 pages. Philadelphia: Hanley & Belfus Inc; 1997. $39.00.

Respiratory Care Pearls is the eighth book in The Pearls Series, containing 75 neonatal, pediatric, and adult patient presentations that emphasize typical clinical problems faced by respiratory care clinicians. The Pearls format uses a problem-oriented approach that brings out important teaching points. A brief clinical scenario, physical examination, and laboratory findings, along with a radiograph or other pertinent illustration, are provided with each case study. The reader is encouraged to utilize his or her expertise in assessment and reasoning skills and to formulate a therapeutic plan. Problems include not only pathophysiologic processes, but also setting up, monitoring, and troubleshooting equipment. Subsequent management issues are developed and 3 critical points, or "take-home pearls," are emphasized at the end of each discussion, along with the clinical outcome of the patient.

The authors state that this book is intended for respiratory therapists, physicians, fellows, residents, nurses, students, and academicians who are interested and challenged by the complexity of the ever-changing specialty of respiratory care. They succeed in their goal of providing a primary respiratory text for the practicing clinician that emphasizes both theory and clinical application.

The editors have developed a consistent format and style in this and the other Pearls Series books, which are meant to challenge the reader by presenting the important features of a clinical problem and directing attention to an especially significant, "cutting-edge" or not widely recognized aspect of patient management specific to that case. Consequently, each reader, from the beginning student to the seasoned respiratory therapist, nurse, or physician, will find something of value in each patient presentation.

The text is clear, straightforward, and easy to read and each case lists several key references. The index is useful in quickly locating specific diagnoses and treatment. Though a student might find it difficult to formulate a differential diagnosis, the 75 patient presentations provide ample opportunity for the more advanced practitioner to utilize complex clinical problem-solving skills that should lead to improved clinical care of patients. Any practitioner involved in providing respiratory therapy or utilizing its associated technology, and particularly one preparing for his or her board examinations, will find this text particularly beneficial.

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Pulmonary Rehabilitation Administration and Patient Education Manual. Kathleen V Morris PhD RN RRT and John E Hodgkin MD. Loose-leaf binder, illustrated, 448 pages. Gaithersburg MD: Aspen Publishers Inc; 1996. $135.00.

Looking at chronic obstructive pulmonary disease (COPD) epidemiology, you will find that presently there is a 71% increase in mortality rate in COPD and it is the fourth most common cause of death in the United States. COPD is the only major disease with rising prevalence and mortality; it was associated with approximately 105,000 deaths in 1997. At present it is estimated that there are 16 million U.S. citizens with the illness, including those with chronic bronchitis, emphysema, and asthma. Over 500,000 hospitalizations per year and over 14 million office visits are generated by this devastating disease. It is also estimated that it will cost over 15 billion dollars to care for such individuals, ranging from hospitalization to home care.

Looking at the magnitude of COPD, one can better understand the work necessary to help these patients incorporate pulmonary rehabilitation into their daily lives. The reader of this manual can better understand its use and importance in the treatment of COPD. Both authors are of the highest caliber in the arena of pulmonary rehabilitation in its the clinical, research, and marketing aspects. Drs Kathleen V Morris and John E Hodgkin have been collaborators in promoting pulmonary rehabilitation for many years in California and in the nation and are regarded as experts in the field. To the practicing pulmonologist, respiratory therapist, nurse, and other health care provider caring for COPD patients, the design of this manual can be used at all levels of patient care.

This manual is divided into 4 parts with a detailed index. It is presented in a loose-leaf binder format to facilitate easy access to specific sections for the purpose of reproduction, since the reader is allowed to reproduce materials for patient or program use. Part One is divided into 2 sections. Section 1 will take the reader from definitions through outcome measurements to enable even the beginner in pulmonary rehabilitation to understand the content of a pulmonary rehabilitation program, and to allow the reader to design a proposal for a program to fit all settings and budgets. All necessary tools, from patient selection to patient interview and discharge planning, are well explained. Section 2 goes into some detail regarding departmental goals and objectives and defines the role of the many disciplines involved in pulmonary rehabilitation. Part One also addresses the reimbursement process, which, in this country, differs from state to state.

Over a decade ago I started a pulmonary rehabilitation program in a midsized hospital, and I can reassure you that Part Two would have been a welcome addition to my beginning program. In developing a new program, one devotes a countless amount of time to creating forms and finding instruments to facilitate the day-to-day operation. Part Two is named simply "Forms." All forms presented here can be reproduced for use as is, or modified and customized for each program's specific needs. It contains 5 sections. Section 1 guides you through a series of available lung health questionnaires to see which would best fit your program. Section 2 takes you into the assessment process to help target areas of intervention and formulate goals and objectives for the patient's individualized program. Section 3 covers the charting process to assure medical necessity, goals with plan-of-action and progress reports, and examples of SOAP (Subjective Objective Assessment Plan) notes. Section 4 covers patient home recommendations, and Section 5 includes reimbursement ideas and post-program follow-up.

Part Three of this manual, a patient handbook, is of great value to any size program from the small beginning program to the most advanced. It consists of 206 pages of valuable information designed with the patient in mind. It cover topics ranging from the anatomy of the lungs to self care and traveling ideas. The index of topics is 3 pages in length. All topics are in layman's terms. This section is also a valuable source of information in helping the beginning practitioner to learn how to educate the patient.

Part Four provides detailed lesson plans to guide you through the task of designing your program from education to exercising the COPD patient. The lesson plans emphasize key points on one half of the page with feedback on the other half and an overview of all topics necessary in each educational group sessions. A detailed index completes the manual.

All in all, I found this manual a valuable addition to my pulmonary rehabilitation library. Although it could be an overwhelming manual to the beginner practitioner, it covers the entire basis and research necessary to start a pulmonary rehabilitation program. The book should be considered one of the best reference manuals available in pulmonary rehabilitation; it is by far the most comprehensive manual on how to understand and undertake pulmonary rehabilitation to improve the quality of life for all patients suffering from COPD.

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AARC Clinical Practice Guideline

Single-Breath Carbon Monoxide Diffusing Capacity, 1999 Update

DLCO 1.0 PROCEDURE

Single-breath diffusing capacity for carbon monoxide ($DLCO_{sb}$), sometimes referred to as the transfer factor for carbon monoxide (TCO).

DLCO 2.0 DESCRIPTION/DEFINITION

The first American Association for Respiratory Care (AARC) single-breath diffusing capacity ($DLCO_{sb}$) Clinical Practice Guideline (CPG) was published in 1993, and was based largely on the American Thoracic Society (ATS) 1987 recommendations.[1] Since that time, the ATS has published new recommendations.[2] This updated AARC CPG reflects the 1995 ATS recommendations. Various methods are commercially available to perform $DLCO_{sb}$. This Guideline can be applied in many (perhaps most) cases and is based on experience and research with the traditional method (10-second breathhold with alveolar sample collection). For non-traditional or newer methods, it is the manufacturer's and the scientific community's responsibility to define the comparability of the newer methods with the old.

Diffusing capacity is a measurement of carbon monoxide (CO) transfer from inspired gas to pulmonary capillary blood. During the test, the subject inspires a gas containing CO and one or more tracer gases to allow determination of the gas exchanging capability of the lungs. Although several different methods of measuring DLCO have been described, the most commonly used technique is the single-breath maneuver, or $DLCO_{sb}$. For purposes of this guideline, recommendations associated with the $DLCO_{sb}$ are referenced.[2] Many of these standards apply indirectly to other methods of measuring diffusing capacity.

2.1 DLCO is usually expressed in $mL\ CO\ min^{-1} \cdot torr^{-1}$ at standard temperature and pressure dry (STPD).

2.2 The alveolar volume (VA) at which the $DLCO_{sb}$ is measured is also commonly reported; the units for the VA are liters at body temperature and pressure, saturated with water vapor (BTPS).

2.3 The ratio of DLCO to VA is also commonly reported as the DL/VA or simply D/VA.

DLCO 3.0 SETTINGS:

3.1 Pulmonary function laboratories
3.2 Cardiopulmonary laboratories
3.3 Clinics
3.4 Physicians' offices

DLCO 4.0 INDICATIONS:

Tests of diffusing capacity may be indicated for (Specific conditions and direction of change in DLCO are shown in the Appendix.):

4.1 evaluation and follow-up of parenchymal lung diseases including: idiopathic pulmonary fibrosis (IPF, also known as usual interstitial pneumonitis, or UIP) and bronchiolitis obliterans organizing pneumonia (BOOP, or cryptogenic organizing pneumonia, COP), diseases associated with dusts such as asbestos, or drug reactions (eg,from amiodarone) or related to sarcoidosis;[1-3] and for quantification of disability associated with interstitial lung disease; [4]

4.2 evaluation and follow-up of emphysema and cystic fibrosis;[5,6] and differentiating among chronic bronchitis, emphysema, and asthma in patients with obstructive patterns; and for quantification of impairment and disability.

4.3 evaluation of cardiovascular diseases (eg, primary pulmonary hypertension, acute or recurrent thromboembolism, or pulmonary edema);[7,8]

4.4 evaluation of pulmonary involvement in systemic diseases (eg, rheumatoid arthritis, systemic lupus erythematosus);[9-11]

4.5 evaluation of the effects of chemotherapy agents or other drugs (eg, amiodarone, bleomycin) known to induce pulmonary dysfunction;[12-14]

4.6 evaluation of pulmonary hemorrhage;[15]

4.7 as an early indication of certain pulmonary infections (eg, pneumocystis pneumonia);[16]

4.8 prediction of arterial desaturation during exercise in some patients with lung disease.[17,18]

DLCO 5.0 CONTRAINDICATIONS

5.1 Absolute contraindications to performing a diffusing capacity test are

5.1.1 the presence of carbon monoxide toxicity

5.1.2 dangerous levels of oxyhemoglobin desaturation without supplemental oxygen.

5.2 Relative contraindications to performing a diffusing capacity test are

5.2.1 mental confusion or muscular incoordination preventing the subject from adequately performing the maneuver or inability to obtain or maintain an adequate lip seal on the instrument mouthpiece;

5.2.2 a large meal or vigorous exercise immediately before the test;[1]

5.2.3 smoking within 24 hours of test administration (smoking may have a direct effect on DLCO independent of the effect of COHb[19]);

5.2.4 decreased lung volumes that would not yield valid test results;

5.2.5 devices that are improperly calibrated or maintained or the unavailability of a qualified operator.

DLCO 6.0 HAZARDS/COMPLICATIONS:

6.1 $DLCO_{sb}$ requires breathholding at total lung capacity (TLC); some patients may perform either a Valsalva (higher than normal intrathoracic pressure) or Müller (lower than normal intrathoracic pressure) maneuver. Either of these can result in alteration of venous return to the heart and pulmonary capillary blood volume.

6.2 Interruption of supplemental oxygen may result in oxyhemoglobin desaturation.

6.3 Transmission of infection is possible via improperly cleaned mouthpieces or as a consequence of the inadvertent spread of droplet nuclei or body fluids (patient-to-patient or patient-to-technologist).

DLCO 7.0 LIMITATIONS OF METHODOLOGY/VALIDATION OF RESULTS:

7.1 Limitations of the common methods used for DLCO include:

7.1.1 DLCO should be corrected for hemoglobin (Hb) level according to the method described by Cotes and co-workers.[20]

7.1.1.1 For adolescent boys(≥ 15 years of age) and adult men, the Hb is adjusted to a value of 14.6 g/dL:

$$\text{Hb-adjusted DLCO} = \text{observed DLCO } (10.22 + \text{Hb})/1.7\ \text{Hb}.$$

7.1.1.2 For children < 15 years of age and women the Hb is adjusted to a value of 13.4 g/dL:

$$\text{Hb-adjusted DLCO} = \text{observed DLCO } (9.38 + \text{Hb})/1.7\ \text{Hb}.$$

7.1.2 For purposes of interpretation, DLCO should be corrected for the effects of COHb present in the subject's blood.[1]

$$\text{COHb-adjusted DLCO} = \text{measured DLCO } (1 + [\%\text{COHb}/100]).$$

7.1.3 DLCO increases with increasing altitude and appropriate correction for the alveolar or inspired oxygen pressures are recommended.[1]

$$\text{Altitude-adjusted DLCO} = \text{measured DLCO } (1.0 + 0.0035(P_AO_2 - 120])$$

or

Altitude-adjusted DLCO = measured DLCO $(1.0 + 0.0031(P_{IO2} - 150])$ (where estimated $P_{IO2} = 0.21$ [PB - 47 torr].)

7.1.4 A 4-minute minimum interval should elapse between subsequent maneuvers to allow test gas to be eliminated from the lungs.[1]

7.1.5 DLCO varies with body position; the upright seated position is recommended.

7.1.6 Abnormal breathholding maneuvers (Valsalva or Müller) alter DLCO.[21]

7.1.7 Other factors that may alter measurement of DLCO include recent alcohol consumption,[22] vigorous exercise, smoking, diurnal variation, and bronchodilators.[23]

7.1.8 Pregnancy (first trimester only) has been reported to be associated with an increase in DLCO.[24] Menstruation may also influence DLCO.[25]

7.1.9 Breathhold time should be calculated using the method of Jones-Meade.[2] Other methods may produce significantly different results.

7.2 Large interlaboratory differences in measured DLCO and in percent-of-predicted DLCO have been observed [26,27] and are attributed to variations in testing techniques and computational algorithms and errors in gas analysis. The choice of equipment may also influence the measured DLCO.[27,28]

7.3 Choice of reference equations may affect the final interpretation of measured DLCO values.[29]

7.4 Validation of the testing technique and equipment may include but is not limited to

7.4.1 Volume accuracy of spirometer should be < ± 3% over an 8-L volume (ie, meets or exceeds all ATS recommendations[2]) and must be checked each day that the test is performed, using a 3.00 L (minimum) syringe. Spirometer must maintain accuracy with varying gas concentrations .

7.4.2 Gas analyzers should be subjected to a 2-point calibration before each test. Manufacturers should be encouraged to provide software and techniques by which analyzer linearity may be easily checked (eg, dilution technique). Gas analyzer linearity should be

7.4.2.1 within ± 1%, from zero to full span, of maximal value over the duration of the test,

7.4.2.2 formally checked at least quarterly.[30]

7.4.3 Timing device should be checked every 3 months[30] and be accurate within ± 1% over a 10-second period.

7.4.4 The entire circuit resistance should be < 1.5 cm H_2O/L/s at a flow of 6 L/s. The addition of in-line filters may cause the circuit resistance to exceed recommendations.

7.4.5 The apparatus dead space should be < 0.1 L. In-line filters need to be accounted for when determining entire system dead space as well as discard volume (before alveolar collection).

7.4.6 Demand valve sensitivity of < 10 cm H_2O is required for 6 L/s flow through a valve and circuit (if a compressed gas source is used).

7.4.7 Chemical absorbers (for CO_2 and H_2O) or selectively permeably tubing should be replaced at the frequency recommended by the manufacturer, when saturated (as indicated by color change) or sooner. In addition, the chemical absorbers should be placed in the proper order (ie, CO_2 absorber should precede H_2O absorber), should be replaced when exhausted, and should be arranged according to how alveolar gas is analyzed.

7.4.8 Normal standard subjects (biologic controls) may be used to establish intrasubject coefficient of variation and to serve as a quality control population.[2]

DLCO 8.0 ASSESSMENT OF NEED (see Section 4.0 Indications)

DLCO 9.0 ASSESSMENT OF TEST QUALITY:

Individual test maneuvers and results should be evaluated according to the ATS recommendations.[2]

9.1 Use of proper quality-controlled equipment.

9.2 Provision of test instructions before testing commences and determination that the subject is able to follow commands.

9.3 Inspiratory volume exceeding 90% of the largest previously measured vital capacity (FVC or VC), attained in < 2.5 s in healthy subjects and within 4 s in patients with moderate to severe airway obstruction.

9.4 Breathhold times of 9-11 seconds, with no evidence of leaks or Valsalva or Müller maneuvers.

9.5 After the breathhold, there should be appropriate clearance of dead space (anatomic plus system) and proper collection and analysis of alveolar gas.

9.5.1 The washout volume (ie, dead space) should be 0.75-1.00 L or 0.50 L if the subject's VC is less than 2.0 L. If a washout volume other than 0.75-1.00 L must be used, it should be noted.

9.5.2 If an in-line filter is used, when determining discard volume, the filter dead space must be accounted for.

9.5.3 For alveolar-gas sample-bag systems, the volume of the alveolar gas sample should be 0.5-1.0 L obtained in < 4 seconds.

9.6 Two or more acceptable tests should be averaged; the DLCO values should be reproducible to within 10% or 3 mL CO · min^{-1} · torr^{-1}, whichever is greater. We recommend empirically that no more than 4-6 maneuvers be performed.

9.7 The subject should have refrained from smoking for 24 hours prior to the test; however, because subjects do not always comply, the time of the last smoking event should be recorded.

9.8 Corrections for Hb, COHb should be included as noted above (Sections 7.1.1 and 7.1.2); correction for tests performed at altitude is recommended. If Hb correction is made, both the corrected and uncorrected DLCO values should be reported.

DLCO 10.0 RESOURCES

10.1 Equipment:

10.1.1 Volume-measuring device must meet or exceed ATS recommendations.

10.1.2 Appropriate gas analyzers dependent on the methodology employed; certified calibration gases for use before each series of measurements.

10.1.3 COoximeter for analysis of total Hb and COHb is strongly recommended.

10.2 Personnel: Diffusing capacity tests should be performed under the direction of a physician trained in pulmonary function testing. The value of diffusing capacity results can be compromised by poor patient instruction secondary to inadequate technologist training. Thus, technologists should have documented training, with continued competency assessments in diffusing capacity administration and recognition of errors encountered in the testing process as well as a sound understanding of pulmonary pathophysiology. Diffusing capacity testing may be performed by persons who meet criteria for either Level I or Level II.

10.2.1 Level I: The technologist performing DLCO should be a high school graduate or equivalent with a demonstrated ability to perform basic pulmonary function studies such as spirometry (and $DLCO_{sb}$). Level 1 personnel should perform DLCO tests only under the supervision of a Level II individual or a physician.

10.2.2 Level II: Personnel supervising DLCO testing should have formal education and training (as a part of a program in respiratory therapy or pulmonary function technology or 2 years of college in biological sciences and mathematics) and 2 or more years performing spirometry, lung volumes, and diffusing capacity tests.[31] One or more of the following credentials is recommended: RPFT, CPFT, RRT, CRT.

DLCO 11.0 MONITORING: (Also see Section 9.0 Assessment of Test Quality)

The following should be evaluated during the performance of the DLCO measurement to assess the validity of the results:

11.1 Acceptability of the maneuvers and reproducibility of $DLCO_{sb}$:

11.1.1 patient positioning: subjects should be seated for at least 5 minutes prior to testing and should remain seated throughout the DLCO testing session,

11.1.2 interval between tests: at least 4 minutes between sequential tests to allow elimination of tracer gas,

11.1.3 reproducibility, with at least 2 acceptable tests that are within ± 10% or 3 mL CO(STPD)/min/mm Hg of the average DLCO.

11.2 Level of understanding (of test instructions), effort and cooperation by the subject.

11.3 Equipment function or malfunction (eg, calibration), with equipment quality control performed as recommended, any time accuracy is suspect or if the equipment is moved to a different location.

11.3.1 Volume calibration and leak testing performed on a daily basis,

11.3.2 Gas analyzer linearity checked quarterly,

11.3.3 Timer tested quarterly

11.3.4 Tests on standard subjects (biologic controls, or bio-QC)should be performed at least on a quarterly basis ***and*** any time accuracy is suspect.[2]

11.3.4.1 Standard subjects should be tested more frequently initially to establish statistical variation for comparison.

11.3.4.2 It is advantageous to perform Bio-QC at weekly or semi-monthly intervals.[32]

11.4 Reference equations: each laboratory should select reference equations appropriate for the methods and the population tested.

11.5 Inspired oxygen concentration: test gas concentration should be 20.93% and at sea level pressure. Subjects should remain off supplemental oxygen for at least 5 minutes prior to performing the first test. Technologists should document (in the final report)a patient's inability to remain off supplemental oxygen for the allotted time.

11.6 The final report should contain a statement about test quality.

11.7 The final report should contain the DLCO, the corrected DLCO (Hb, COHb, altitude), and the Hb value used for correction. The alveolar volume (VA) and DL/VA (ie, the ratio of diffusing capacity to the lung volume at which the measurement was made) may be included in the report. These values are helpful for purposes of interpretation. The final report should indicate which method was used to correct the raw DLCO value and for what the DLCO value is being corrected [eg, corr DLCO (Hb), corr DLCO (CO)].

11.8 $DLCO_{sb}$ results should be subject to ongoing review by a supervisor, with feedback to the technologist. Quality assurance (QA) and/or quality improvement (QI) programs should be designed to monitor the technologist both initially and on an ongoing basis.

DLCO 12.0 FREQUENCY:
The frequency at which DLCO measurements should be repeated depends on the clinical question(s) to be answered.

DLCO 13.0 INFECTION CONTROL:
Diffusing capacity tests are relatively safe procedures, but the possibility of cross-contamination exists, either from the patient-patient or patient-technologist interface.[33]

13.1 Technologists should exercise Standard Precautions for all patients, follow recommendations of the Centers for Disease Control and Prevention for control of exposure to tuberculosis and droplet nuclei, and, in addition, institute appropriate precautions empirically for airborne, droplet, and contact agents pending confirmation of diagnosis in patients suspected of having serious infections.[33]

13.2 Proper use of barrier devices (eg, protective gloves) may be useful to prevent spread of contagion via direct contact. Hand washing must always be performed between patients, and protective gloves must be worn if there are open cuts, or sores, on the technologist's hands.[2]

13.3 Due to the nature of the DLCO maneuvers and the likelihood of coughing when the test is performed by subjects with known or suspected active infection with *Mycobacterium tuberculosis* or other airborne organisms, recommended precautions are:[34]

13.3.1 The room in which the DLCO test is performed should meet or exceed the recommendations of U.S. Public Health Service[33,35] for air changes and ventilation. The ideal situation is to establish an area in the testing department specially ventilated for isolation patients. We strongly recommend that, if this is not possible, the patient be returned to the isolation room as soon as possible, and the testing room be closed for a minimum of 1 to 2 hours.

13.3.2 Pulmonary function technologists performing procedures on patients with potentially infectious airborne diseases should wear a personal respirator that meets OSHA recommendations, especially if the testing itself induces coughing.[35]

13.4 The mouthpiece, tubing, and any parts of the system that come into contact with the subject should be disposable or sterilized between patients. If sterilization is not feasible, then high-level disinfection should be performed. It is unnecessary to routinely clean the interior surface of the spirometer.

13.4.1 Visible condensation, from expirate, warrants cleaning of the system before testing another patient.

13.4.2 Bacterial filters that allow rebreathing may be used in circuit, although their efficacy is not well documented. However, such filters may impose added resistance during inspiration or expiration and affect the timing of the DLCO maneuver. If a filter is used, the filter dead-space volume should be considered in the calculation of DLCO and VA.

Diffusion Capacity Working Group

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Appendix Follows

APPENDIX

Factors that Result in a Decrease in DLCO

Factor	Condition Giving Rise to Factor
Deficiency in red blood cells	Anemia
Loss of pulmonary capillary bed with relatively normal lung volume	Multiple pulmonary emboli, early collagen-vascular disease, early sarcoidosis, miliary tuberculosis
Loss of functioning alveolar-capillary (A-C) bed with increased lung volume	Emphysema
Loss of functioning A-C bed with decreased lung volume	Parenchymal restrictive processes including pulmonary resection, idiopathic interstitial fibrosis, asbestosis, scleroderma lung disease, histiocytosis-X, sarcoidosis, pneumonia
Failure of inspired air to reach alveoli, or poor distribution of ventilation with low, normal or increased lung volume	Seen occasionally with severe obstruction during asthmatic or bronchitic attack; seen frequently with emphysema and poor effort

Factors that Result in an Increase in DLCO

Factor	Condition Giving Rise to Factor
Increase in pulmonary capillary blood volume	Left heart failure, left-to-right shunt (atrial septal defect, anomalous pulmonary venous return), exercise
Increase in red blood cells	Early polycythemia

Specific Abnormalities Leading to an Increase in DLCO*

Abnormality	Precipitation Condition
Lung compression	Scoliosis, obesity, pectus excavatum
Increased airway resistance	Asthma, cystic fibrosis, central airway lesions
Pulmonary vascular congestion	Congestive heart failure, regurgitative valvular disease
Intrapulmonic hemorrhage	Pulmonary hemosiderosis, Goodpasture's syndrome, hemothorax
'Physiologic' leaks	Tympanic rupture, tracheoesophageal fistula

*The clinician should be suspicious if a patient with any of the abnormalities and/or precipitating condition listed proves to have a normal diffusing capacity.

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New Products & Services

Ventilator. Pulmonetic Systems Inc has announced that its new LTV 1000 ventilator has received 510(k) clearance for continuous life supporting ventilation in institutional and transport settings as well as in the home. A company press release says the device is intended to provide mechanical ventilation for pediatric and adult patients in a hospital or health care facility and that it can be used for intra- or interfacility transport. Pulmonetic says the LTV 1000 is completely self contained, weighs less than 13 pounds, contains its own battery source, and does not require compressed air. The company also says approval for the device for home care use is pending. For more information from Pulmonetic Systems Inc, circle number 195 on the reader service card in this issue, or send your request electronically via "Advertisers Online" at http://www.aarc.org/buyers_guide/

Ventilator Antidisconnect Device. Pepper Medical Inc introduces two new products for ventilator users. The company says it's Ventilator Antidisconnect Device consists of a trach neckband coupled with a patented antidisconnect strap. Company literature says the strap aids in preventing ventilator disconnections at the trach site and describes the device as a fully adjustable soft cotton neckband using Velcro® tabs. For more information from Pepper Medical Inc, circle number 196 on the reader service card in this issue, or send your request electronically via "Advertisers Online" at http://www.aarc.org/buyers_guide/

Ultrasonic Nebulizer. Siemens introduces the Servo Ultra Nebulizer 145 (SUN 145), a stand-alone ultrasonic nebulizer for ventilated patients. A Siemens press release says the device provides ultrasonic nebulization for patients ranging from neonate to adult and adds that it can be moved among any conventional ventilator systems. The company says the SUN 145 provides a stable particle size and that it requires no change in ventilatory settings because medication is given via predetermined ventilator settings. Siemens also says the device boasts easy maintenance with disposable medication cups and an easy-to-clean nebulization chamber. For more information from Siemens, circle number 197 on the reader service card in this issue, or send your request electronically via "Advertisers Online" at http://www.aarc.org/buyers_guide/

Spirometer. DHD Healthcare has introduced its Coach 2™ volumetric incentive spirometer. A company press release says features of the new device include a one-way valve, a bedrail holder for easy patient access, universal graphics and brightly colored piston, and an O_2 connection. DHD says they have also introduced the Coach 2 for Kids™, a 2,000 mL capacity incentive spirometer for the pediatric patient, complete with brightly colored stickers, puzzles, and games designed to make incentive spirometry fun and progress easy to monitor. For more information from DHD Healthcare, circle number 198 on the reader service card in this issue, or send your request electronically via "Advertisers Online" at http://www.aarc.org/buyers_guide/

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Review Article: A comprehensive, critical review of the literature and state-of-the-art summary of a pertinent topic that has been the subject of at least 40 published research articles. Title Page, Outline, Introduction, Review of the Literature, Summary, Acknowledgments, References. Tables, Appendices, and Figures and Captions may be included.

Overview: A critical review of a pertinent topic that has fewer than 40 published research articles.

Update: A report of subsequent developments in a topic that has been critically reviewed in this Journal or elsewhere.

Point-of-View Paper: A paper expressing personal but substantiated opinions on a pertinent topic. Title Page, Text, References, Tables, and Illustrations may be included.

Special Article: A pertinent paper not fitting one of the foregoing categories may be acceptable as a Special Article. Consult with the Editor before writing or submitting such a paper.

Editorial: A paper drawing attention to a pertinent concern; it may present an opposing opinion, clarify a position, or bring a problem into focus.

Letter: A signed communication, marked "For publication," about prior publications in this Journal or about other pertinent topics. Tables and illustrations may be included.

Blood Gas Corner: A brief, instructive case report involving blood gas values—with Questions, Answers, and Discussion.

Drug Capsule: A mini-review paper about a drug or class of drugs that includes discussions of pharmacology, pharmacokinetics, and pharmacotherapy.

Graphics Corner: A brief case report incorporating waveforms for monitoring or diagnosis—with Questions, Answers, and Discussion.

Kittredge's Corner: A brief description of the operation of respiratory care equipment—with information from manufacturers and editorial comments and suggestions.

PFT Corner: Like Blood Gas Corner, but involving pulmonary function tests.

Cardiorespiratory Interactions. A case report demonstrating the interaction between the cardiovascular and respiratory systems. It should be a patient-care scenario; however, the case—the central theme—is the systems interaction. CRI is characterized by figures, equations, and a glossary. See the March 1996 Issue of RESPIRATORY CARE for more detail.

Test Your Radiologic Skill: Like Blood Gas Corner, but involving pulmonary medicine radiography and including one or more radiographs; may involve imaging techniques other than conventional chest radiography.

Review of Book, Film, Tape, or Software: A balanced, critical review of a recent release.

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Center main section headings on the page and type them in capital and small letters (eg, Introduction, Methods, Results, Discussion). Begin subheadings at the left margin and type them in capital and small letters (eg, Patients, Equipment, Statistical Analysis).

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Article in a journal carrying pagination throughout volume:

> Rau JL, Harwood RJ. Comparison of nebulizer delivery methods through a neonatal endotracheal tube: a bench study. Respir Care 1992;37(11):1233-1240.

Article in a publication that numbers each issue beginning with Page 1:

> Bunch D. Establishing a national database for home care. AARC Times 1991;15(Mar):61,62,64.

Corporate author journal article:

> American Association for Respiratory Care. Criteria for establishing units for chronic ventilator-dependent patients in hospitals. Respir Care 1988;33(11):1044-1046.

Article in journal supplement: (Journals differ in their methods of numbering and identifying supplements. Supply sufficient information to promote retrieval.)

> Reynolds HY. Idiopathic interstitial pulmonary fibrosis. Chest 1986; 89(3 Suppl):139S-143S.

Abstract in journal: (Abstracts citations are to be avoided. Those more than 3 years old should not be cited.)

> Stevens DP. Scavenging ribavirin from an oxygen hood to reduce environmental exposure (abstract). Respir Care 1990;35(11): 1087-1088.

Editorial in journal:

> Enright P. Can we relax during spirometry? (editorial). Am Rev Respir Dis 1993;148(2):274.

Editorial with no author given:

> Negative-pressure ventilation for chronic obstructive pulmonary disease (editorial). Lancet 1992;340(8833):1440-1441.

Letter in journal:

> Aelony Y. Ethnic norms for pulmonary function tests (letter). Chest 1991;99(4):1051.

Paper accepted but not yet published:

> Hess D. New therapies for asthma. Respir Care (year, in press).

Personal author book: (For any book, specific pages should be cited whenever possible.)

> DeRemee RA. Clinical profiles of diffuse interstitial pulmonary disease. New York: Futura; 1990. p. 76-85.

Corporate author book:

> American Medical Association Department of Drugs. AMA drug evaluations, 3rd ed. Littleton CO: Publishing Sciences Group; 1977.

Chapter in book with editor(s):

> Pierce AK. Acute respiratory failure. In: Guenter CA, Welch MH, editors. Pulmonary medicine. Philadelphia: JB Lippincott; 1977:26-42.

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Calendar of Events

AARC & AFFILIATES

June 8–11—*Hollywood Beach, Florida*
The FSRC hosts its Sunshine Seminar, "Respiratory Care: Crossing the Bridge to the 21st Century" at the Clarion Hotel. Up to 24 CEUs are available through the seminar, plus an additional eight for optional workshops. Topics include case management, sleep medicine, hyperbaric medicine, cystic fibrosis, and Y2K pitfalls and perils.
Contact: For more information, call (954) 522-6269.

June 16–18—*Oakbrook, Illinois*
The 1999 ISRC annual convention and exhibition will be held at Drury Lane Theatre and Conference Center in the Chicagoland area. Topics will include management and subacute, with opportunities under PPS, maximizing career potential and survival techniques for respiratory care. Breakout sessions include mechanical ventilation, blood gas regulation update, and CO-oximetry.
Contact: Mike Lawrence at (618) 234-2120, ext. 1287, or e-mail **mlawrence@lclsnet.lcls.lib.il.us**.

June 16–18—*Round Top, New York*
The New Jersey and New York State Societies for Respiratory Care are jointly sponsoring their 12th annual respiratory care spring forum, formerly known as the managers/educators "rocking chair" conference. Workshops include leadership development, stress management, and development of competencies for care delivery at alternate sites. The forum will be held at Riedlbauer's Resort, and CRCE credit has been requested.
Contact: Ken Wyka at (201) 288-3959 or Joe Sorbello at (315) 464-6872 for more information.

August 25–27—*Cleveland, Ohio*
The OSRC state conference will be held at the Holiday Inn in Independence, just south of Cleveland. Specialty sessions include critical care, pediatrics, rehab/continuing care, research, and management.
Contact: Joe Huff at (216) 861-6200, ext. 3892, **ewlu18a@prodigy.com** or Nancy Johnson at (330) 929-7166, **abbyru@aol.com**.

October 1—*Melville, New York*
The NYSSRC's Southeastern Chapter hosts their 31st annual symposium, "Respiratory Care — A Work in Progress," at the Huntington Hilton Hotel in Melville, Long Island. The keynote address will be given by Carl Wiezalis, vice-president of the AARC.
Contact: For information, call Jim Ganetis at (516) 444-3181 or **www.nyssrc.org**.

October 20–22—*Daniels, West Virginia*
The West Virginia Society for Respiratory Care will host its Annual Fall Meeting at the Glade Springs Resort, Country Inns and Suites.
Contact: For more information, contact Jay Wildt, co-chair of program and education, at (304) 442-7474.

Other Meetings

June 12-16, 1999—*International Society for Aerosols in Medicine*
12th International Congress at the Austria Center in Vienna, Austria. Topics include aerosol drug delivery, aerosol deposition and clearance, cellular and molecular interactions, environmental aerosols, standardization, aerosol diagnostics, and aerosol therapy.
Contact: Vienna Academy of Postgraduate Medical Education and Research. Alser Strasse 4, A-1090 Vienna, Austria. Phone (+43/1) 405 13 83-22, fax (+43/1) 405 13 83-23, e-mail medacad@via.at.

August 19–20—*Cleveland, Ohio*
The Cleveland Clinic Foundation is sponsoring a continuing education program titled "Respiratory Therapy," which has been approved for Category 1 accreditation. It will be held at the Omni International Hotel.
Contact: For more information, call Laurie Martel at (216) 444-5696 or (800) 862-8173.

October 1–3—*Ottawa, Ontario, Canada*
The Canadian COPD Alliance will host "Building and Enriching Partnerships in the Management of COPD" at the Radisson Hotel Ottawa Centre. This conference will include plenary sessions on the epidemiology of COPD and scientific workshops on spirometry, smoking cessation, and the evidence to support management approaches to COPD. Included is a series of practical workshops on rehabilitation and a parallel consumer track for those who live with COPD.
Contact: call (613) 747-6776 or see their web site at **www.lung.ca/CCA/conference**.

October 4–5—*Ann Arbor, Michigan*
The Office of Continuing Medical Education at the University of Michigan is sponsoring a conference. "Update on Pulmonary and Critical Care Medicine," at the Towsley Center.
Contact: For more information, contact Laura Castellanos at (734) 647-8784.

www.rcjournal.com

Notices

Notices of competitions, scholarships, fellowships, examination dates, new educational programs, and the like will be listed here free of charge. Items for the Notices section must reach the Journal 60 days before the desired month of publication (January 1 for the March issue, February 1 for the April issue, etc). Include all pertinent information and mail notices to RESPIRATORY CARE Notices Dept, 11030 Ables Lane, Dallas TX 75229-4593.

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Helpful Web Sites

American Association for Respiratory Care
http://www.aarc.org
- Current job listings
- American Respiratory Care Foundation fellowships, grants, & awards
- Clinical Practice Guidelines

National Board for Respiratory Care
http://www.nbrc.org

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http://www.rcjournal.com
- 1997 Subject and Author Indexes
- Contact the editorial staff

Asthma Management Model System
http://www.nhlbi.nih.gov

The National Board for Respiratory Care—1999 Examination Dates and Fees

Examination	Examination Date	Examination Fee
CRTT (CRT) Examination	November 13, 1999 Application Deadline: September 1, 1999	$120 (new applicant) 80 (reapplicant)
RRT Examination	December 4, 1999 Application Deadline: August 1, 1999	120 written only (new applicant) 80 written only (reapplicant) 130 CSE only (all applicants) 250 Both (new applicants) 210 Both (reapplicants)

For information about other services or fees, write to the National Board for Respiratory Care, 8310 Nieman Road, Lenexa KS 66214, or call (913) 599-4200, FAX (913) 541-0156,or e-mail: nbrc-info@nbrc.org

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New Additions to AARC Web Site Make Communication Easy

The AARC's web site (www.aarc.org) make communication with the AARC Executive Office and among other AARC members much more direct and accessible. Recent additions to the site include:

Chat — AARC members can chat in real time. Organized chats on specific topics will be planned in the future.

Just Ask — Do you have a question about AARC policies or positions on issues? Do you need help in interpreting reimbursement and government policies? Do you want to know what the AARC is doing about legislative advocacy? You can post a question in this area for possible posting.

Hotline to the President — Do you want immediate action from the top? Click on the "red phone" hotline to President Dianne Kimball. An E-mail will be sent directly to her.

Help Line — Do you have a clinical or professional question you want answered? Post it on the help line and other AARC members will respond.

Specialty Section Mailing Lists — If you are a member of one of the nine specialty sections, you have instant networking capabilities through the electronic mailing lists of each group.

Patient Assessment Course for Respiratory Therapists

Due to overwhelming demand, the patient assessment course for respiratory therapists is being offered twice this year. The first test date has passed, and the remaining test will be conducted in Phoenix, Arizona from July 18-20 (immediately following Summer Forum). Space is at a premium and preregistration is required. Successful completion of the course will earn participants 16 hours of CRCE credit and a certificate of course completion. Each attendee will be given a pocket guide to physical assessment, to help them on the job. Following the last class, participants will take a 100-item test developed by the NBRC. Tests will be graded on-site for those wishing to obtain their scores immediately. For more information and to register, visit the AARC web site at www.aarc.org.

AARC, Affiliates Set Conference Schedules

The AARC and many of the affiliates have set their schedules for 1999 conferences and seminars. Foremost among AARC's offerings are its Summer Forum (July 16-18) and Annual International Respiratory Congress (Dec. 13-16). Check out the AARC's website at www.aarc.org for all meeting registration materials and a list of affiliate conferences.

Videoconference Program Set; Nursing CEUs Offered

A series of eight videoconferences are scheduled for 1999 through the AARC Professor's Rounds series, which are now approved for nursing CEUs as well as CRCE credit. Topics are: respiratory assessment, asthma management, ventilator management, disease management, pediatric emergencies, COPD, PEEP, and respiratory pharmacology.

CRCE Online Debuts

Now you can earn continuing education on the Internet from the AARC through its new CRCE Online website. After you pay for the number of continuing education units you wish to attempt (by submitting your credit card number on a secure server site), you are given access to the list of courses. Read the material, take the test, and then print out a certificate showing you passed. Your participation will also be noted on your CRCE record with the AARC. Log on to the AARC's website at www.aarc.org and look for CRCE Online.

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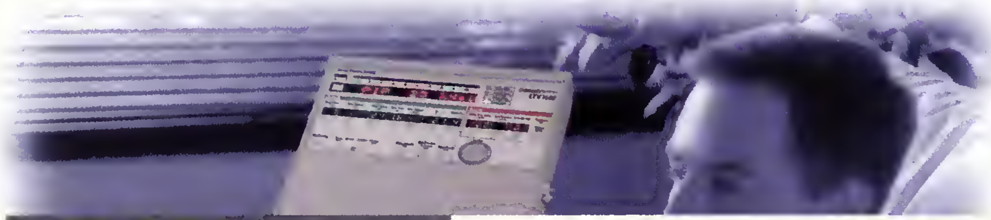

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[1] Mahlmeister MJ, Fink JB, Hoffman GL, Fifer LF, "Positive-expiratory-pressure mask therapy: Theoretical and Practical Considerations and a Review of the Literature", *Respiratory Care*, 1991; 36:1218-1230.

[2] Ibid.

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